# BELL TELEPHONE QUARTERLY

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# BELL TELEPHONE QUARTERLY

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## The Telephone Switchboard—Fifty Years of History

REDUCED to its fundamentals the physical plant of that vast thing we designate as the "telephone system" centers about three elements, namely, the subscriber's substation apparatus with its transmitter and receiver for projecting and receiving sound and its bell or other signaling apparatus for attracting his attention; the wires or other transmission channels which serve to carry the electrical impulses to and from the subscriber's equipment, and the switchboard which serves to interconnect the subscribers' equipments in any desired manner, at any desired time and at the behest of users.

The innumerable multitude of intricate physcial things involved in the make-up of the modern telephone plant are merely adjuncts required to insure the proper functioning of one or other of these elements. The widespread and far-reaching activities of manufacture and supply incident to the telephone business are merely the means by which we provide these fundamental elements in the quantities, at the times and in the places required by the demands of the great telephone using public.

The hundreds of thousands of men and women who spend their lives in the telephone service are in the last analysis the providers, maintainers and operators of these three essential elements.

Whatever else it may have or be, no telephone service is a really satisfactory service unless it provides its customers adequate means for establishing an easy and satisfactory channel of communication from every customer to any other customer, as the whim or necessity of the person desiring to speak may dictate, and at a price for the service which is reasonable, as measured by the standards by which society judges such things to be reasonable. Since the ultimate object of everyone who initiates a telephone call is to converse easily with some correspondent, it is clear that efficiency of transmission is at the very base of the whole telephone structure. Not only must the transmitters and receivers of the substation equipment be adequate and reliable, but the entire channel from substation to substation, be it long or short, must be efficient, not only as regards transmission without substantial distortion of the complex electrical currents which represent speech, but must also be free from unnecessary interruption or the presence of extraneous and disturbing currents.

To facilitate the establishment of the desired connection, to supervise the integrity of that connection when established, and to release the lines or channels for other service when the conversation is finished, necessitate the provision of various signalling devices which must, in the main, operate over the same wires as are employed in the transmission of speech. Indispensable as this signaling is to the functioning of the telephone system as an interconnecting network of speech channels, it has no necessary direct connection with the efficiency of speech transmission. If occasion arose it might in fact be accomplished over circuits which had no electrical connection whatever with the circuits employed by the telephone users when carrying on conversation.

Since permutations and combinations between individual subscribers' instruments are legion, it is not surprising that a very large part of the physical machinery and a very large part of the human labor incident to the giving of telephone service is involved in what is commonly known as the "telephone switchboard"—that center at which innumerable radiating circuits can be connected one with the other. In the fifty years which have elapsed since telephony first began to develop as a service we have gone a long ways from that first embryonic contrivance which, mounted on something long and wooden, served to fasten a name to an essential part of the telephone plant.

During the years which have elapsed, the switchboard has evolved and grown until now it bears little outward resemblance to its first forebear. In fact many of our modern central offices, which serve as the centers for line interconnection, contain little that could properly be designated as a "board", although much of switching machinery.

Throughout all the period, however, certain fundamental principles have persisted, and so far as anyone can see will continue to persist; for example, every switchboard must provide easy, rapid and certain means of finding, and connecting to, the line desired to be reached. It must provide ways and means for receiving and understanding the desires of the originating subscriber, whether these desires are conveyed by the spoken word to a human being, the operator, or by means of electrical impulses to her mechanical alter ego in the automatic telephone system. It must likewise provide the machinery for attracting the attention of a distant party and for knowing when the use of a connection that has been established is finished.

We commonly think of our thousands of central office switchboards and our tens of thousands of private branch exchange boards, scattered throughout the length and breadth of the land, as rather separate entities. Actually

they are merely parts of a single complex organism which for convenience or economy we have found it desirable to decentralize.

There is no hard and fast rule which determines just where a switchboard should be located or just what subscribers it should serve. Every development which tends to better or cheapen one of the three fundamental elements of the telephone plant alters somewhat our ideas concerning the size, character and location of our central offices. A few years ago it seemed clear that the economical and efficient thing to do was to locate each switchboard as nearly as possible in the center of the subscribers' area to be served and to have that area only of moderate dimensions. Today, in many instances, we find our central offices coming to be located on the outskirts of the territory to be served, and with area relatively great in extent. This change is the direct result of improvements which have tended to cheapen and make more efficient the channels of communication, combined with the effect of improvements in the switchboard itself.

The communication channels which interconnect the switchboards within a great metropolitan area, and the long distance lines which criss-cross the country and form the interconnecting network between cities, towns and hamlets, are in the last analysis merely the extended wires which link together parts of a single switching machine. Despite the fact that they may be replete with loading coils, repeaters and a thousand and one auxiliary devices, and require for their operation a complex organization of human beings, they are functionally no different in their purpose from many of the wires which connect together different parts of a switchboard within the same central office.

If transmission channels were substantially without cost and with an efficiency which was substantially independent of length, one might conceive of a nation served telephonically through a single gigantic switchboard at some central point. From this switchboard would radiate

lines or channels to every subscriber's instrument, and at it would be performed the function of interconnecting the subscribers' lines as desired. There would be no inter-office trunks or long distance lines as we now have them. In a word, we would have on a huge scale what we now have for local service on a small scale in every single-office city or town.

Even if such a switching arrangement were possible physically and economically, we would find, however, that in the arrangement of our imaginary central office factors of convenience, economy and simplicity would still dictate our associating the subscribers' lines together in larger or smaller groups.

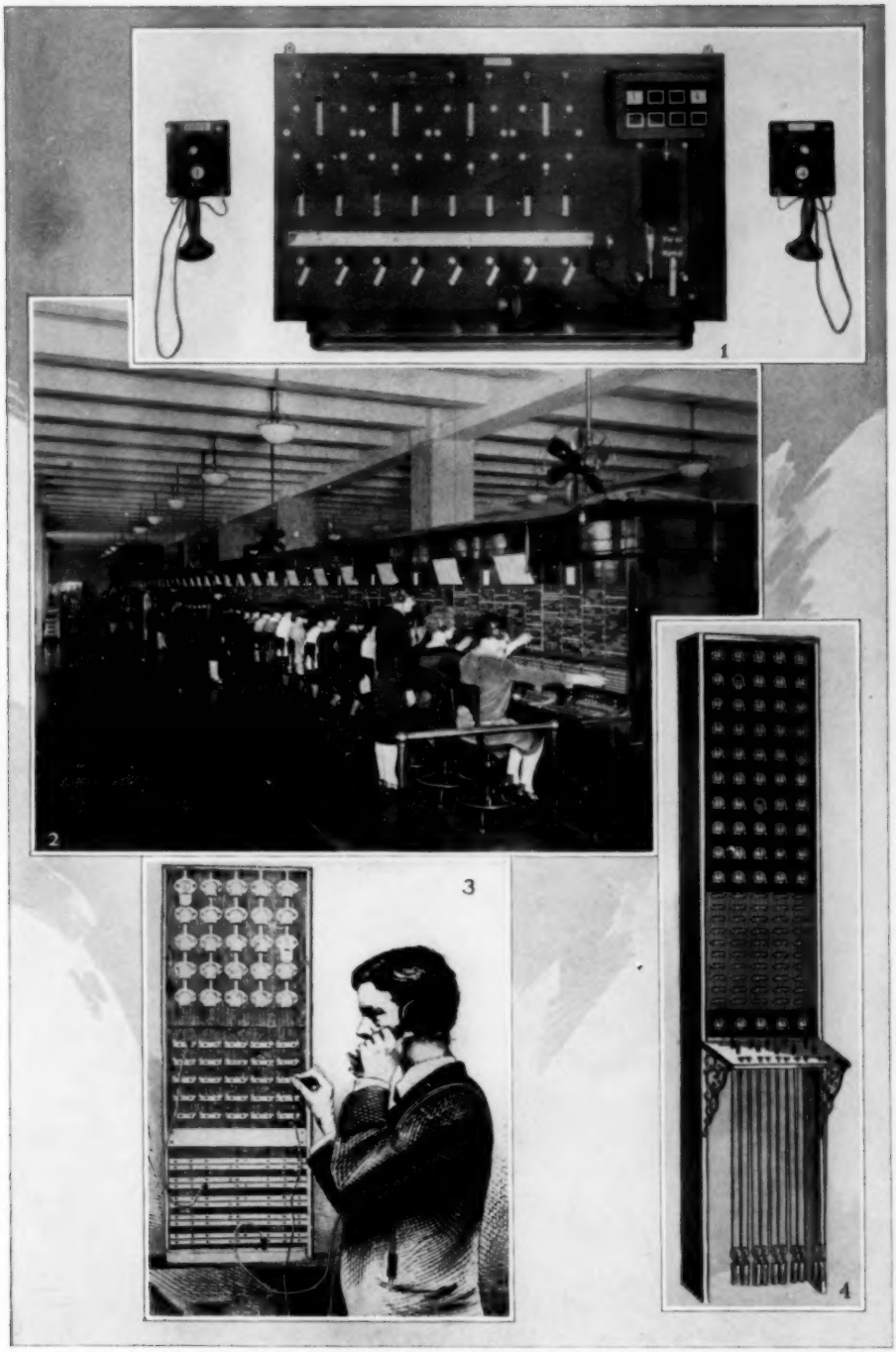
Limitations of human intercourse result in by far the largest proportion of telephone conversations being essentially local in character. What we would end up with therefore would be divisions of our central switchboard more or less corresponding to our towns and cities, or the main subdivisions of the latter. With such a division, and still adhering to our assumption that the cost and efficiency of transmission channels were substantially independent of length, there would then be no reason why the various units should not be located in or near the group of subscribers directly connected with them, if there were reasons of convenience or economy in such a location. Such reasons of convenience and economy do exist, so that the tendency to concentrate great numbers of subscribers' lines at a single common point, which has been going on in our big cities for a number of years past, would seem to be subject to quite definite limitations, irrespective of what we may do in the future further to diminish the cost and increase the efficiency of transmission channels.

While fifty years of research, development and operating experience have put us in possession of a vast amount of knowledge which permits of our engineering central office switchboards and their proper locations with a high degree of accuracy, the development of our present

situation was the result of an expanding knowledge acquired largely in isolated situations having no immediate connection with similar problems at a distance.

In its early days the telephone was essentially an instrument for a very local use. Even after improvements had been made in the transmitter, the receiver, transmission line and the interconnecting switchboard, the telephone plant was still entirely the aggregation of independent groups of local subscribers. As time went on and the utility of the telephone became more apparent to people generally, the demand for it grew to such proportions that within individual cities subscribers could no longer be handled economically through a single switchboard. At the same time improvements in telephone transmission means were made and the possibility of giving service between more and more widely separated communities came into the picture. In step with these changed conditions came the improvements in the original crude switchboards which have brought us to where we now are and have laid the groundwork for our future development in switching mechanisms.

The first commercial telephone switchboard was put in service in New Haven, Connecticut, on January 28, 1878. Eight lines, with a total of twenty-one subscribers, were connected to this pioneer board, a picture of which, together with pictures of the subscribers' instruments of that time, is shown in Fig. 1. Contrasting with this simple contrivance is a section of typical manual switchboard in use in January, 1928, shown in Fig. 2. Switchboards of this character have a capacity of ten thousand subscribers' lines. The striking difference in appearance between the two boards, although indicative of the progress that has been made, is entirely inadequate to show the real measure of what has transpired in a half-century of switchboard development. The changes and improvements are too deeply buried in the intricacies of the circuits and equipment to be superficially evident. Although the date of installation of the first switchboard is




(1) Model of first commercial telephone switchboard, installed at New Haven, Conn., January 28, 1878, with two "butterstamp" receivers that served for talking, listening, and receiving signals. (2) Modern metropolitan central office. (3) The "Universal" switchboard of 1879. (4) The "Standard" switchboard of 1880.

well established, dates for the numerous improvements which immediately began to appear are for the most part uncertain.

Theodore N. Vail in a letter dated June 26, 1879 to H. W. Pope, General Superintendent of the New York Company, laid down the general policy of the parent company. It was that the local companies should adopt the best apparatus available and then adopt improvements as fast as they arose. Since there was at the time no central manufacturing company for telephone apparatus, it resulted inevitably that every little shop equipped to manufacture telephone apparatus immediately entered the field of production and applied the inventive genius of its own staff to the task of development. Improvements were constantly being made in dozens of places throughout the country and any strict chronological account of all that transpired is a practical impossibility.

Because of the entire absence of an art in 1878, the first New Haven switchboard exhibits quite naturally the methods and apparatus then used elsewhere in the simple electrical industry of the time. Rotary arm brass switches were used and two of them had to be operated to make a connection between lines, while a third had to be employed to connect the operator into the circuit, and a fourth to signal the called subscriber. No means whatever had to be provided for determining whether the line to the called subscriber was in use, since the operator had visible evidence of its condition in the position of the rotary switch. Signaling was accomplished by sending over the line to the subscriber's station, current from a buzzer, later known as Coy's chicken, which caused all the receivers on the line to give out a grating sound which might or might not attract the subscribers' attention. If the particular subscriber wanted happened to be one of those who heard and answered, all of the others presumably hung up, unless perchance they were overly interested in the affairs of their neighbors. There was no

way for the subscriber to call the central operator after a connection had been established, nor was there any way for the operator to know when the conversation was finished except by the process of listening in on the line. A single telephone receiver used at the subscriber's station served both for talking and listening.

During the first four or five years of switchboard development, and before a centralized manufacturing control had been established, many peculiar and almost fantastic types of switchboards were evolved. There was one which resembled a pyramid in appearance, another looked like a big table with the operators sitting around it sticking pegs in little holes in its surface. A stranger might easily have obtained the impression that they were playing some new and curious form of cribbage. Carbon transmitters were adopted during these first few years, as were also hand driven magneto generators for signaling purposes. Originally boy operators were used in these early central offices, from two to four being required to complete each call. As all orders were passed by word of mouth the confusion which existed, even in a small central office, may well be imagined. With the advent of young women as operators and with improvements in equipment, the operating rooms ultimately became the quiet orderly places which are such a striking feature of present-day manual switchboard practice.

Improvements in switchboards first took the form of better and more conveniently arranged apparatus. Only a year after the installation of the New Haven switchboard a type called the "Universal Switch" manufactured by the Western Electric Manufacturing Company (the predecessor of the present Western Electric Company) showed some quite progressive steps in the direction of meeting the growing needs of telephone service. Unlike most of the previous boards, a large part of the apparatus on this switchboard was designed especially for telephone use. Fig. 3 shows the operator answering a call on this board. The shutter type annunicator drops

taken from the existing signaling art, were mounted conveniently at the top of a vertical board rather than in a box. So-called "jack knife" switches, one for each line, mounted flat on the face of the board, were introduced in place of the rotary arm switches. The name "jack knife" as applied to this switch, resulted from its having a part shaped like the blade of a jack knife, which opened a contact when a plug was inserted. Connecting and ringing strips all mounted compactly and conveniently were provided. This board, like its forerunners, accommodated a comparatively small number of lines. As the number of lines in a central office increased, additional switchboards were set up side by side.

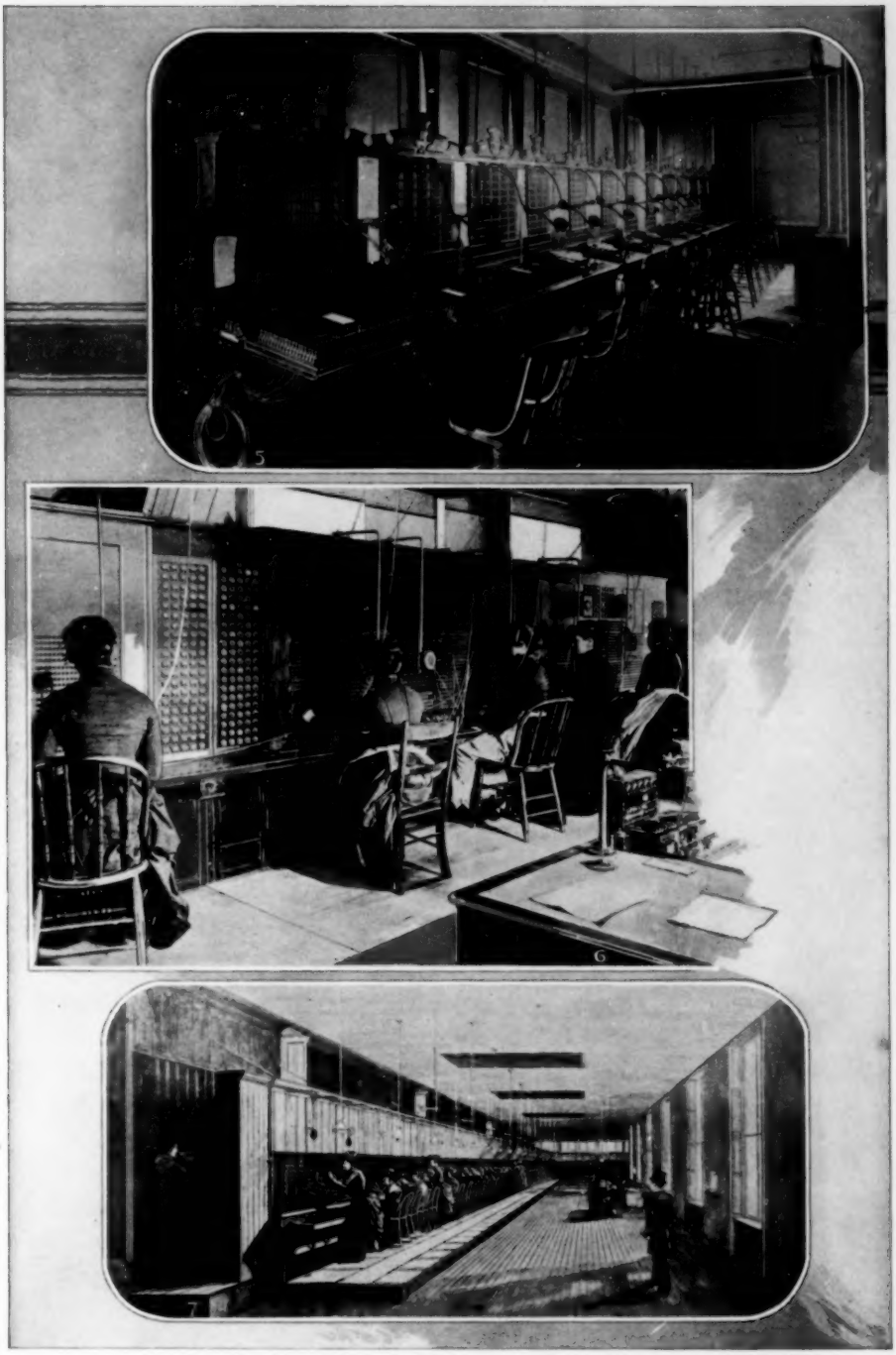
In 1880, less than two years after the original New Haven switchboard, the Western Electric Manufacturing Company brought out what was known as the "Standard" switchboard. An illustration of this board is shown in Fig. 4. The design and general arrangement of apparatus on it was indicative of the course manual switchboard development was to follow. With the increasing size of exchanges, adequate space for the mounting of jacks and other apparatus was becoming a critical question. This board, with its convenient arrangement of parts, permitted the mounting side by side of sections which together could take care of a total of two or three hundred lines. With it were introduced the key shelf and the cord circuit, the latter consisting of a fixed pair of connecting cords provided with cord weights, each associated with a clearing-out signal or drop and with ringing keys. Shortly after the appearance of this board the spring jack was developed to replace the jack knife switch, thereby effecting a great economy in space much needed in the handling of the increased number of lines to be connected.

All of the early switchboards were of the single-unit type manned by a single operator. As the number of subscribers grew, an additional unit and operator had to be placed beside the first operator. The operators made

interconnections between their boards by reaching across in front of each other. One operator could handle the calls for one hundred to two hundred subscribers at the most. When the number of subscribers increased so that three operators became necessary, the operator in the middle could reach lines on both sides but the two outside operators had great difficulty in making the cross connections. At first cords were passed across by the middle operator but later so-called "transfer" trunks came into use. These trunks or tie circuits connected each operator's position with positions otherwise out of reach. Connections were made by one operator calling out the subscriber's number desired to the distant operator, who replied with the number of the transfer trunk to be used. Fig. 5 shows part of an early switchboard of thirty positions equipped with these transfer trunks.

A basic principle of switchboard operation is that so far as possible each operator must be able to complete a connection to any line terminating in her office. The use of transfer trunks was merely an intermediate step in the solution of this problem. A complete solution was found in the idea incorporated in the multiple board invented by L. B. Firman of the Western Electric Manufacturing Company. The first installation of this type of board with a complete multiple within the reach of each operator was made in 1882 and had a capacity of two hundred subscribers. An early board of this type was that at Milwaukee in 1883, shown in Fig. 6. Soon boards were installed with an ultimate capacity of 2,400 subscribers.

The term "multiple switchboard," which is a common designation today, was derived from the fact that in the Firman board each line was connected to a jack within the reach of each operator. In addition to the multiple jacks each operator had on the lower part of the panel before her a smaller number of jacks—perhaps one hundred—to which were connected the lines which she was to answer. In a central office of two thousand lines there were thus twenty operators, each answering the incoming



(5) "Gilliland" switchboards in the office of the Telephone Dispatch Company, Boston, 1883. (6) Three sections of an early multiple switchboard. (7) "B" section of the Cortlandt Street Exchange, in New York City, in 1887.

calls of one hundred lines, and each of the two thousand lines was multiple connected to jacks within the reach of each operator. The development of the telephone jack of small size made possible the incorporation of this idea by providing a ready means by which a large number of terminals could be concentrated in a small space.

Since the multiple arrangement is obviously practicable only if the operator has a ready and quick means of knowing whether or not the line she wishes to connect to is busy, some method had to be devised for giving each operator this information, as otherwise confusion or double connections would be the rule. C. E. Scribner devised a circuit so arranged that when the operator touched the tip of her plug to the metallic sleeve at the opening of the subscriber's jack a click was produced in her telephone receiver if the line was in use. If no click was heard she knew that the line was not otherwise in use and that she could therefore complete the connection.

By this time improvements were being made in rapid succession. The circuits which heretofore had consisted of one metallic wire and a ground return were changed to completely metallic circuits at the suggestion of J. J. Carty. While this change was initiated primarily as a method of improving line transmission, it had a far-reaching influence on switchboard development and construction. Also about this time, and as a result of the increasing number of lines which had to be handled in the switchboard, apparatus which was previously mounted in the section of the board came to be mounted on racks at a distance and connected with the positions of the switchboard by cables.

From the time General Carty introduced the idea of two wire circuits without ground return, switchboards handling such circuits came to be known as the "metallic" type boards. The first multiple switchboard employing full metallic circuits with an ultimate jack capacity for ten thousand subscribers' lines (Fig. 7) was installed in the Cortlandt Street office, New York City, in 1887. By

reason of the peculiar trough shaped keyboard to provide for the mounting of the line signals below the cords, this switchboard was known by the suggestive name of the "hog trough" type.

Passing over the innumerable array of improvements in apparatus, such as the self-restoring drop, the improved jacks, cords and other apparatus, the next milestone in switchboard progress was the introduction of the common battery at the central office, which did away with the individual batteries for current supply on the subscribers' premises. The supersession of the great number of individual subscriber's local batteries by one large storage battery at the central office, in addition to providing for better telephone transmission, also opened the door to a method by which the subscriber could attract the attention of the operator merely by removing his receiver from the switch hook.

Incidentally, one of the major problems which had to be solved in the use of the common battery was to devise a way of supplying a large number of lines from it simultaneously without annoying crosstalk from one circuit to another. The two most suitable types which emerged from the great amount of experimentation on this problem were the Hayes repeating coil system, the invention of Mr. Hammond V. Hayes, formerly Chief Engineer of the American Telephone and Telegraph Company, and the Stone-Scribner bridged impedance type cord circuit patented in 1896 by Mr. Scribner, then Chief Engineer of the Western Electric Company. The Hayes system, which uses a repeating coil or transformer, is in improved form employed in practically all Bell System manual common battery switchboards of today, as well as in the most modern panel type automatic systems. The first installation of the repeating coil cord circuit was in the Lexington switchboard mentioned below. The Stone-Scribner bridged impedance type of battery supply is employed today in improved form in all step-by-step dial telephone exchanges.

The first installation using common battery for talking and signaling was at Lexington, Mass., in 1893. The board there installed was of the non-multiple type using drop signals. A multiple board with common battery and lamp signals was installed in Worcester, Mass., in 1896, but this installation still employed local batteries for talking. The first use of common battery for both talking and signaling in conjunction with a multiple board was in Louisville, Kentucky, in 1897.

One of the most potent factors influencing switchboard design and operating methods was the development of a miniature incandescent lamp for giving line and clearing-out signals. These lamps were used in the Worcester and Louisville boards and marked a great step in advance in telephone switchboards. The old drop signals required valuable space on the already overcrowded face of the switchboard. Lamps on the contrary were not only economical of space but eliminated the noise and confusion due to the falling and restoring of drops and therefore lent themselves better to the development of automatically controlled circuits, which were then beginning to come into use. The employment of incandescent lamps for line signals was first proposed by Mr. J. J. O'Connell of the Chicago Telephone Company, and such lamps were used on local battery switchboards installed in Chicago in 1894. For purposes of supervision the use of lamps was a great boon to the operator as she could tell at a glance from the appearance of two small lamps when the called telephone was answered and when the subscribers had finished talking.

Out of the development and introduction of metallic circuits, common battery current supply and lamp signals, came the whole transition in telephone operating practice which removed from the subscriber the necessity of performing a separate mechanical function to signal the operator and placed in the hands of the operator a quick, easy and accurate method of supervising the establishment and disestablishment of connections.

With the growth of telephone use subscribers became so scattered over large areas that the efficient handling of the service indicated the necessity for several central offices within one exchange area. The different offices were tied together with lines called "trunks." Calls coming into an office where a subscriber was within the same office area could be completed by the answering operator, but if they were for a subscriber in another office the answering operator would connect the calling line into a circuit going to the desired office and the operator there would complete the call.

This development, which evolved from the expanding use of the telephone, led to the division of switchboards into two classes known as "A" and "B" boards. The "A" operators would complete calls going to subscribers in the same office but calls to other offices would be plugged into trunks running to "B" boards in those offices. The "B" operator would then complete the calls to the subscribers in her office.

For many years the best standard practice required the use of a special circuit known as a "call" circuit between the "A" and "B" operators. This circuit was employed wholly by the operators for passing of information incident to the establishment of a connection. It did not form a part of the subscribers' talking circuit. A very important development in recent years has been the elimination of these call circuits by what is known as the "straightforward trunking" method. In this method the "A" operator selects an idle trunk to the distant office and passes the number of the called party over the same trunk that is used for the call. This method not only saves time but reduces errors, as the subscriber hears the "A" operator repeating the number and can make sure it is correct.

Switchboards for handling long distance calls, commonly referred to as "toll boards" have passed through an evolution paralleling that of the manual local board. The major trend in exclusively toll board improvement

has been toward decreasing the time that a subscriber must wait before having his call completed. An important recent improvement has been the introduction of a system known as "combined line and recording," in which the subscriber desiring a connection to a distant party may be connected in a manner similar to that employed for straightforward trunking as used within a single exchange area. With this system it is now possible to complete a very large percentage of toll connections while the calling subscriber remains at the telephone.

The switchboards thus far described have all been of the manual type. In these boards the lines terminate in jacks in front of operators, and while many functions, such as ringing, may be done automatically, the essential work of determining the number desired, completing the connection and restoring the lines to normal on the completion of conversation, is done manually by a human being, the telephone operator.

From the very early days of switchboard development, and particularly after the introduction of the common battery and lamp signal, much of the progress involved a transfer of functions from the operator to automatic machinery. After a time the progress in this direction had proceeded so far that the question began to be raised as to whether ultimately it might not be possible to eliminate the operator entirely as part of the machinery for establishing many kinds of telephone connections.

To recount the progressive development of the details of automatic switching, which for the past thirty years has paralleled the development of other forms of switchboard, would be too great an undertaking for this short historical sketch of switchboard development. Basically all forms of automatic switching involve the substitution of electrical impluses for the voice of the originating subscriber in making known his desires, and the substitution of electrical machines for human beings at the central office as the means for interpreting these desires

and performing the functions of switching in accordance therewith. Modern panel type automatic switching equipments, such as are employed in our great metropolitan areas, are so complex as to require the concentrated attention of specialists for their comprehension. Their senders and decoders, and the myriad of intricate mechanisms with which they are associated, are almost human in their action. All that can be attempted therefore is merely an outline of some of the major steps.

Patents covering an automatic switching system were first applied for in 1879 by Daniel Connelly, T. A. Connelly and T. J. McTighe. Their system never became a commerical success. In 1889, however, A. B. Strowger invented a system which was successfully developed by A. E. Keith and other engineers of the Automatic Electric Company and is successfully used at the present time under the name of the "step-by-step" system.

Other automatic systems containing important features contributing greatly to the success of automatic switching have appeared both in this country and abroad. Among them are the Lorimer system, first operated in 1897, that of Lattig, Goodrum and Dunham for which a patent was applied in 1903, and that of E. E. Clement dating from 1906.

The Bell System became engaged actively in the development of automatic switching equipment before 1900. With its vast interest in telephony and its desire in every way to perfect and simplify the operation of switching, it sought to determine fundamentally the type of machinery best applicable to the needs of a universal service.

As a result of long extended and searching inquiry, a large installation of automatic equipment was made in Newark, New Jersey in 1914. In this installation the central office equipment was of the so-called "panel" type. The installation was designed not as a final test of a complete automatic system but as a test on a large scale of the efficacy of the central office machinery which

seemed most likely to give the desired results when applied to a complete automatic system.

In the Newark installation, which was known as a "semi-mechanical" system, the subscribers called the operator in the usual manner but from the operator onward the call was completed entirely by the use of automatic switches. As a result of the experience with the first installation in Newark, and with subsequent modified installations in Newark and Wilmington, the primary details of the panel system were perfected. This done, the stage was set for the final act and the first exchange having complete automatic operation with panel type switches was made in Omaha in 1921. Since that time the application of dial telephones has grown rapidly until at the present moment more than twenty per cent. of the telephones in the Bell System are operated on a dial basis, through either panel or step-by-step switches.

In looking back at the first switchboard in New Haven it is clear that we have come a vast distance in these fifty years, but in view of the developments of the last seven or eight years he would be overbold who would predict that the developments of the next fifty years would not equal them in magnitude.

FRANK B. JEWETT.

# Interruptions on Telephone Conversations Some Causes and Preventive Measures

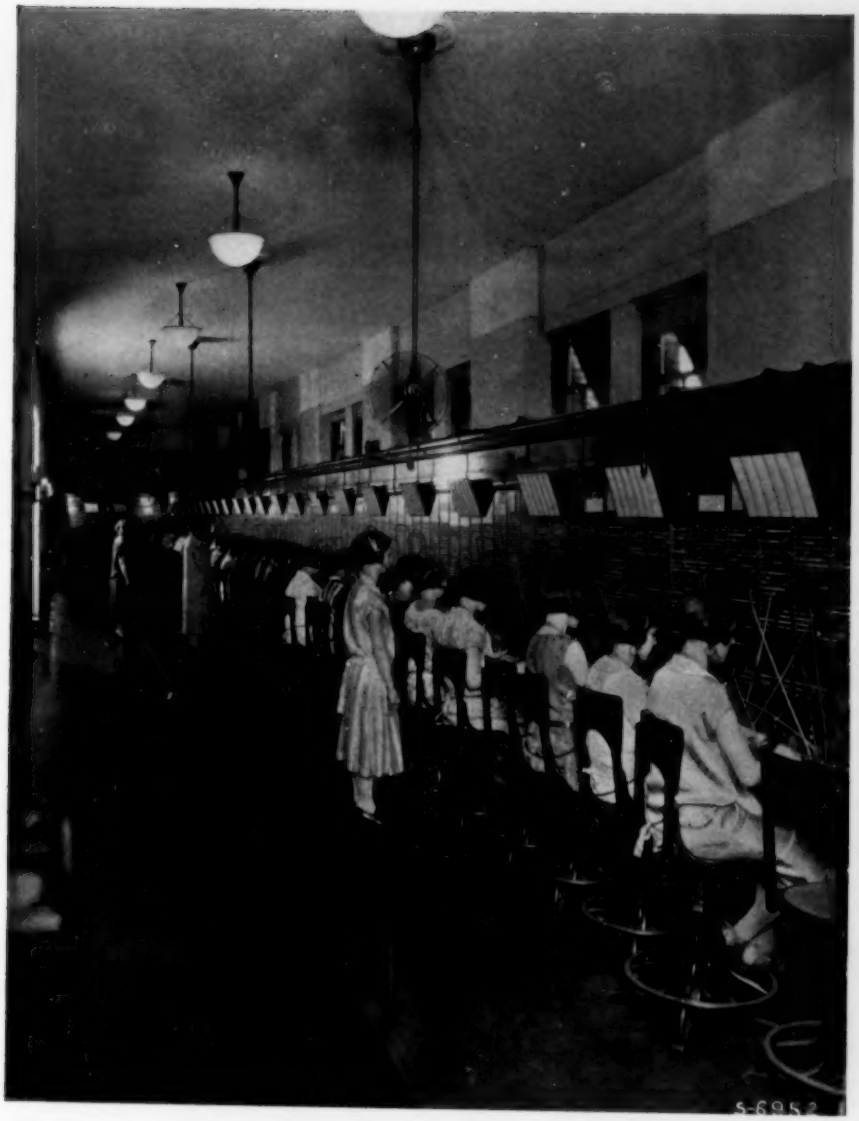
## The "Cutoff"

It occasionally happens that a telephone conversation which is proceeding satisfactorily is interrupted by what is technically called a "cutoff". Although cutoffs are relatively infrequent, the annoyance to users is great, not only because of the interruption itself, but also because of the delay in reestablishing connection which often results when both parties are at their telephones and both are trying to restore the connection. It may be helpful to describe some ways in which cutoffs occur, their average frequency and some of the methods employed to prevent them.

From the viewpoint of the telephone users in the larger cities, interruptions which are generally classed as cutoffs occur on the average, six times in a thousand local conversations. On three of these an actual severing of connection has taken place due to some feature of telephone company operation. The other three are the result of some action at the calling or called station or private switchboard, and in many of these cases the connection, in so far as it is controlled by the telephone company, has not been disturbed. Whatever their cause, the prevention of interruptions is a matter of great concern since about 15 per cent. of the criticisms of operators' work arise from this source.

### *Cutoffs Due to Telephone Operation*

Considering first the three cutoffs per thousand calls attributable to telephone operation, they are due to an accumulation of possibilities for failure inherent both in human effort and in extensive electrical plant. Calls in large cities involve two, and sometimes three, operators. The calling operator illustrated on the photo-



Typical telephone switchboard in operation.

graph of a typical subscribers' switchboard, makes two movable connections by inserting plugs into jacks, and if either is removed by mistake during conversation, a cutoff results. The operator at the called office, and also at the intermediate office, when one is involved, makes one movable connection between plug and jack. Thus there are either three or four points of contact where the connection may be severed purely through an operator's mistake, and such mistakes cause one and a half cutoffs in a thousand calls. Calls passing through a private switchboard also have two additional plugs which might be removed in error, and thus a call from a user at one large business establishment to an extension at another large firm may have seven or more vulnerable points.

Much effort is expended in designing telephone plant to make it proof against mechanical or electrical failures. It is well understood, however, that with any extensive electrical plant involving cords, lamps, coils, relays, soldered connections and other contacts, there are always possibilities for trouble to creep in. A conversation within a large city such as we have been discussing is held over physical plant which includes about 15 movable contacts, some 400 soldered or mechanically secured connections, and 50 other contacts where temporary trouble might develop, causing mechanical breaks in the circuit or giving false disconnect signals to the operator. When the connection passes through private switchboards, about 200 more contacts are added to the line. While the probability of trouble developing at any individual point is very small, the number of such points is large. It is estimated that equipment in trouble of one kind or another causes about half of the cutoffs attributable to telephone company operation, or about one and a half cutoffs in a thousand calls.

Cutoffs on conversations from dial telephones occur less frequently than on connections completed manually. There is less opportunity for human error, although

chances for mistakes at private switchboards and at subscribers' instruments are still present.

In smaller cities where there is only one telephone office, telephone conversations are less likely to be interrupted since only one operator is involved in completing calls and there is considerably less equipment than in the larger places.

Long distance connections, on the other hand, pass through more equipment and involve more operators, and cutoffs average somewhat higher, about ten calls in a thousand being affected in spite of the precautions taken to prevent interruptions. On the average long distance connection there are four operators, not including operators at private boards, and six plugs which might be taken down by mistake. Many long distance calls pass through one or more intermediate offices, with another operator with two cords, added to the operation at each such switching point.

In a long distance cable connection from New York to Chicago, for example, there are about 1,500 relay or key contacts and 9,000 other fixed contacts of different kinds, in addition to some 40,000 soldered connections in the toll line itself. All long distance calls are subject to more physical hazard than local calls, and still more when completed over open wire toll lines than through toll cables. The covered cables afford protection from certain kinds of trouble to which open wires are exposed.

Prevention of cutoffs is a matter which has received careful attention by the telephone organization. Equipment has been designed to throw every practical safeguard against the accidental taking down of talking connections. Operating methods and practices have been worked out to reduce the likelihood of operators' mistakes. Cords and lamps on switchboards are colored alternately white, red and green so that operators can identify connections and give them definite association with the disconnect signals on the position and with the plugs in the particular lines.

The chances for operators' mistakes are greatest when a large number of cords are in use on a position or when a plug adjacent to a talking connection is disconnected. The picture of a typical switchboard illustrates some of the conditions encountered. Considering the complications of handling the calls on switchboards, a remarkable job is done in keeping the number of cutoffs caused by any individual operator down to about one in fifteen hundred calls handled. This is less than one cutoff per operator in a full day's work.

Operators are taught to follow technical practices which will prevent mistakes in disconnecting. Definite ways of selecting cords have been developed to reduce cord tangles to a minimum and methods of tracing cords when congestion is unavoidable are used generally. Operators are taught to disconnect on the calling party's line first so that they will immediately receive a warning light if an error has been made and correct it before the conversation is seriously disturbed.

An operator assisting in taking down connections on an adjacent position safeguards against cutoff by holding plugs with a certain position of the fingers and awaiting teamwork signals from the adjacent operator to indicate that she is taking down the right cords. There are many other measures of this sort in general use, and while some of them seem of little consequence when considered individually, in the aggregate they make substantial contribution to the prevention of cutoffs.

On the equipment side, also, many special practices are necessary to insure proper operation of the equipments. Cords are frequently tested and those found to be defective or in questionable condition are immediately taken out of service.

All central office equipments are given rigid tests frequently for indication of defects. Toll lines and toll equipments which contain complicated apparatus are subject to frequent inspection and constant supervision.

*Cutoffs Due to Other Causes*

Occurrences at subscribers' stations or private boards, which account for about three cutoffs per thousand calls, fall into two general classifications—those which really break down the connection and those which give that impression, although the connection has not been disturbed. Private exchange operators disconnect by mistake in the same way that company operators occasionally do. There is also a possibility of private exchange operators giving false disconnect signals to the company operators in several different ways, and this would, of course, result in the connection being taken down.

In the other group are cases where the private exchange operator fails to follow up calls to extensions slow in answering and fails to advise the calling party of conditions, with the resulting impression of cutoff on his part. The same impression may be given when a particular person has been called to the telephone but is slow to respond, and this may occur at single line stations as well as at private boards. The calling party may disconnect in some of these cases, and when the called party finally comes to the telephone he thinks a cutoff has occurred. Sometimes one party or the other leaves the telephone to look up information and is slow to return, and the impression of cutoff is given to the party waiting. Occasionally a private operator or subscriber, busy with other matters, stops the ringing signal without answering immediately, with the same unsatisfactory result.

Telephone users can therefore make substantial contribution to the improvement of cutoffs. Those having private exchanges have an opportunity to prevent cutoffs or conditions so classed, by making sure their own operators are proficient and that the most efficient telephone practices are employed both by the private exchange operators and extension users. Whenever possible, it is helpful to avoid having the private exchange operator obtain the called party before the calling user comes to the

extension. If the private exchange operators give close attention to calls for extension stations which are slow in answering, some impressions of cutoffs will be cleared up. The telephone companies have specialists on private exchange operation who are always glad to assist subscribers in instruction work and on all matters involving the operation of these boards.

If a cutoff does occur, the quickest way to get the connection reestablished, is for the called user to hang up his receiver and allow the calling user to order the connection restored. This simple rule will help materially to keep out complications and delays which sometimes arise when both parties remain at the telephone and try to restore the connection at the same time.

Considering all the conditions involved, it seems fair to say that the measures taken to prevent cutoffs have reduced this service failure to a low point. Since 1920 there has been a reduction of 40 per cent. in the average number of cutoffs in a thousand calls. Even with a low average, however, these annoyances will not be distributed evenly and some subscribers will receive more than others. As long as there are any such occurrences, their prevention will be a matter of great concern to those responsible for giving telephone service as well as to the subscribers themselves. Constant attention to the matter by the entire telephone organization is therefore necessary, and if users of the service also assist wherever possible, it will always be a valuable contribution.

## Intercepted Calls

Telephone users occasionally ask this question: "After I have given my call to the operator, why does she ask me a few seconds later, 'What number are you calling, please?' " When this condition is encountered, one is likely to think that the operator has forgotten the number and that no progress has been made on his call in the meantime.

The fact is that definite effort has been made to complete his call but that completion has failed, for one of a number of possible causes, and the call has, therefore, been transferred to a special operator called the Intercepting Operator so that the correct action necessary to complete the call may be determined.

In a large city, about twenty-five calls out of a thousand are sent to the Intercepting Operator. Of these twenty-five calls, fifteen require action by the Intercepting Operator, and ten are calls that might have been completed by the regular operators. It may be of interest to consider these two groups of calls separately.

*Calls Properly Routed to Intercepting Operator*

Of the fifteen calls out of a thousand that are properly sent to the Intercepting Operator, thirteen are due to causes over which the telephone company has no control. A subscriber may have moved from one part of the city to another, necessitating a number change, or he may have moved to some other city, necessitating the disconnection of his telephone. Or, perhaps, the number has been changed because of the opening of a new office, brought about by growth.

The remaining two of the fifteen calls in this group are due to a variety of causes, such as a line out of order, an error in the telephone directory, or service temporarily discontinued.

*Calls Improperly Routed to Intercepting Operator*

As noted above, ten calls out of a thousand are sent to the Intercepting Operator instead of being properly completed. About nine of the ten are due to some error on the part of the operator or the subscriber, the errors being equally divided. About one of the ten calls is due to equipment trouble or to a variety of causes.

There is no single outstanding fault that explains this condition but rather a number of causes, some of them

being chargeable to the operator, some to the subscriber, and some to the equipment.

*Errors Due to an Operator*

1. Starts to work on the call before understanding the number desired.
2. Selects a trunk to an office other than the one desired.
3. Passes the digits of the number incorrectly.
4. Passes the number correctly but terminating operator misunderstands it.
5. Terminating Operator understands the number correctly but makes a mistake in selecting the desired multiple jack out of several thousand to which she has access.

*Errors Due to Subscriber*

As is indicated by the following, the calling subscriber may have placed his call in such a way that it was routed to the Intercepting Operator:

1. Relies on his memory and calls a number other than the one he wants, the number called not being in use, and the call therefore being properly routed to the Intercepting Operator.
2. Speaks indistinctly in giving his order to the operator.
3. Dials before hearing the dial tone, forces the dial back, makes an error in dialing, or removes his receiver when another station on the line is dialing.

*Errors Due to Equipment Trouble*

If the call is from a dial telephone, most of the operating errors mentioned above are eliminated but they

are replaced in part by various equipment reactions resulting from the use of additional machinery in place of operators.

*Means for Decreasing Intercepted Calls*

While some intercepting service is an inherent part of the general telephone service, some of the above causes of error are subject to a certain amount of control. Most of this naturally falls on the telephone company but the subscriber may assist materially. Their separate fields are shown below:

*The Telephone Company*

With a view to minimizing the number of calls sent to intercepting operators, the telephone company is working to train all operators to perform their part in establishing telephone connections with the minimum error consistent with any human effort, keeping in mind the importance of accurate service in the design of all new equipment and in the selection of operating methods. Care is also taken to see that all subscribers' lines are connected to the terminals assigned and the entire physical plant is maintained at the highest practical standard. Continual studies are being made with a view to selecting office names subject to the minimum confusion. Efforts are also being made to place in the hands of each subscriber a directory that is free from error and to keep Information and Intercepting records up to date on all changes in listings that occur between directory issues. Subscribers' numbers are not changed except where such changes are unavoidable.

*The Subscriber*

The subscriber may aid materially by consulting the latest issue of the telephone directory if he is at all doubtful of the number of the person desired. If a ready reference list of numbers is kept, it would be well to correct

it after receiving a new issue of the directory. In giving the number to the operator one should speak clearly, with the lips close to the mouthpiece but not against it. If the subscriber is served by a dial office, the number should be dialed in the manner described in the information pages of the directory.

Of course, the above lines of effort are not new either to the subscriber or to the telephone company, but constant effort along the lines mentioned should result in a minimum number of calls routed to the Intercepting Operator.

## "Wrong Number" Calls

Wrong number calls result in annoyance and loss of time, whether the error is attributable to the telephone company's employees, or to the subscribers themselves.

In a large city usually two operators, and sometimes three, are needed to complete a local call. A considerable amount of expensive plant is tied up for a short time on each call. If the call results in a wrong number, the expense for the operating labor and for the equipment involved is entirely wasted, as the operator who answered the call must start her work again.

Since a "wrong number" call is an annoyance both to the person making the call and to the person called in error and since it is objectionable to the telephone company both from the service standpoint and from the standpoint of economy in operation, it may be of interest to consider the causes of wrong numbers and the steps that are taken or that may be taken to minimize them.

In a large city, about twenty-three calls out of a thousand result in a wrong number. Of these twenty-three calls, thirteen are calls on which the telephone company is partly or wholly at fault; ten are calls on which the number given by the person calling was not the number he wanted.

*Wrong Number Calls Attributable to Telephone Company*

As noted above, on thirteen calls out of a thousand the telephone company is partly or wholly at fault. In some cases, the number has been passed clearly to the operator but a mistake has been made by that operator or by another operator involved in completing the connection. In other cases, the number may not have been clearly passed to the operator due perhaps to faulty articulation or to failure to speak into the mouthpiece of the telephone. These cases are included in the thirteen wrong number calls mentioned above.

A further analysis may be made of the thirteen wrong number calls in a thousand that are chargeable to the telephone company. Of these thirteen calls, five are due to a misunderstanding between the operator and the subscriber; six are due to a misunderstanding between operators; one is chargeable to the answering operator for completing the connection to an office other than the one called; one is due to one of several causes, the chief error being charged to the terminating operator for completing the connection to a station other than the one called.

While five wrong numbers in a thousand calls are due to an error between the operator and the calling subscriber, it will be noted that the percentage error is small, only half of one per cent. No service, involving human effort and mechanism, can ever be entirely free from error. As noted above, the call may have been passed clearly and yet misunderstood by the operator, or it may have been subject to faulty articulation or failure to speak into the mouthpiece of the telephone.

The telephone company is wholly responsible for the six wrong numbers in a thousand calls resulting from a misunderstanding between operators. In order to reduce these errors to a minimum, each operator receives training in voice work before she is permitted to handle calls. Because of the similarity in sound between some of the

ten digits in the group from 0 to 9 inclusive, the operators are taught to pronounce each figure in such a way as to minimize the confusion of that figure with any of the other figures. Perhaps the best known example of this is the pronunciation of the figure "3" as "th-r-ee", the letter "r" being slightly rolled. It will also be noted that the figure "4" is pronounced "fo-wer", the figure "5" as "fi-iv" and so on. Since 1920, the wrong numbers for which the telephone company is responsible have decreased from twenty-six to thirteen per thousand calls. A very large part of the gain has been due to more accurate service between operators. The work along this line is necessarily continuous, and it is hoped that some further improvement may be obtained.

It will be noted that one wrong number in a thousand is due to the fact that an operator completes the connection to an office other than the one desired. This is very low when the possibilities for error are considered. In a large city surrounded by a highly developed suburban area, the operator must deal with some hundreds of central office names. In selecting names for offices in a large city, each name is tested by having one operator pronounce it over a telephone circuit to another operator. Lists of names are tested in this manner, the test being repeated many times with different operators. Care is used to select names different in sound from other names in use in that city and in the nearby suburban area.

In order to complete the call, an operator must first select the group of trunks to the desired office and then select an idle trunk in that group. In a large city, the proper trunk group must be selected from a hundred or more groups of trunks located in front of the answering operator. The accompanying photograph will give an idea as to the problem that the operator has in selecting the proper trunk group out of a large number of groups of trunks. Every known method is used to mark the trunk groups clearly and to acquaint the operators with the location of each trunk group. The small percentage of

errors due to these causes indicates that the work is effective.

And finally one wrong number in a thousand calls is due in part to an error of the terminating operator in selecting the proper number out of several thousand numbers in front of her, and in part to a number of causes such as errors in records, errors in connecting a telephone properly to the central office through the overhead and underground cables and the various frames at the central offices, and similar causes. In view of the many possibilities for error that these various causes afford, the actual errors attest the emphasis placed on accurate work by the telephone company in these various phases of the work.

*Wrong Number Requested by the Person Calling*

On ten calls out of a thousand, the number requested by the person making the call is not the number that he really wants. This is usually caused by calling from memory when one is not really sure of the number desired, by calling from an old list of numbers, or similar causes. The service is made to appear somewhat worse when the person who makes the mistake fails to apologize for it on receiving an answer, and charges the mistake to the operator.

While the wrong numbers chargeable to the telephone company have decreased from twenty-six to thirteen out of a thousand calls since 1920, on the other hand the wrong numbers requested by the person making the call have stood at ten out of a thousand calls or now nearly half of the total wrong numbers.

It is the purpose of the telephone company to supply each subscriber with a copy of the latest issue of the telephone directory containing an accurate list of telephone subscribers as of the date of issue. If a listed telephone is later disconnected, special arrangements are made to route a call for this number to an intercepting

operator who will give the calling party the new number of the telephone in question or will tell him that it has been discontinued. If a new telephone is installed, special records are provided at the Information board so that subscribers may readily obtain this number. When the next issue of the directory is made, these special records are then canceled.

It is, therefore, important for a subscriber to consult the directory before making a call instead of calling from memory or from an old list of numbers. The telephone company frequently stresses this point to the end that an increasing proportion of the subscribers will follow this practice with a resultant decrease in the proportion of wrong number calls due to this cause.

*How to Reduce the Proportion of Wrong Number Calls*

The telephone company is constantly working to improve both the equipment and the methods, and as mentioned above the wrong numbers for which the telephone company is partly or wholly responsible have decreased substantially.

The telephone user can help materially in reducing the quantity of wrong number calls by looking up the number in the current issue of the telephone directory, and fixing the office name and the figures of the number well in mind; and by speaking clearly with the lips close to the mouthpiece but not against it. If a dial telephone is used dial the letters of the office name that are capitalized and then the figures of the number followed by the party line letter, if any.

It will be seen from this brief review that there are many conditions which may cause a "Wrong Number" call. Some are wholly within the control of the telephone company and some are wholly within the control of the subscriber. While there will always be some wrong numbers, definite effort by the telephone company and the subscribers, along the lines indicated in this paper, should

result in a decrease in Wrong Number calls and a corresponding improvement in the general telephone service.

### "My Bell Rang" Reports

When one answers a ring on his telephone and is told by the operator that "There is no one on your line now. Will you excuse it, please?" there is naturally annoyance mixed perhaps with wonder at the reason for such a condition. Occasionally the person who was called will ask the operator who called him and he may be further annoyed when he finds that she is unable to tell him.

Before discussing the reasons for these occurrences, it may be helpful to explain that in large cities, each telephone office is equipped with two separate switchboards. At one switchboard, a group of operators answer outgoing calls that are made by the subscribers served by that office, these calls going to the various offices in that city, to nearby toll towns, or to the long distance board. At the other switchboard, a group of operators complete incoming calls to the subscribers served by that particular office, these calls coming from the various offices in the city and out. In a dial office, there is a similar division of the equipment for handling outgoing and incoming calls.

When one encounters a "Bell Rang" condition, it means that a call has been completed to his telephone by an operator at the incoming board in the office serving him, and that the connection at the incoming board has then been taken down for some reason. Under these conditions, when the receiver is removed from the hook, in answer to the ring of the bell, a lamp lights in front of an operator at the outgoing board. This operator has no knowledge of the previous incoming call and can only apologize for the resulting annoyance.

About nine out of a thousand calls result in "Bell Rang" reports. In 1920, this figure stood at twelve, but along with other improvements in the service, this item has gradually improved.

Why should there be any cases of this sort? That is a natural question to ask, and it may be of interest to consider the major irregularities which result in "Bell Rang" reports. In some cases, the telephone company is responsible and in others a subscriber is responsible. In the discussion that follows, the irregularities are grouped in accordance with the responsibility.

*Irregularities Attributable to the Telephone Company*

After a subscriber gives a call to an operator, he presently hears her pass the number to the completing operator. The latter operator then completes the connection to the number called, if it is not busy, and the ringing starts automatically.

Sometimes the calling subscriber notices that his operator made a mistake in passing the number to the completing operator and he corrects the mistake. His operator then disconnects from the trunk first used, and passes the correct number over another trunk to the completing operator. The act of disconnecting from the first trunk gives a signal to the completing operator who then disconnects. The successive operations are so rapid that frequently disconnection occurs before the called station is rung. In other cases, it occurs after the called station is rung, and in that event there is no one on the line when the called station answers. About half the irregularities chargeable to the telephone company are due to this cause. There are, however, a number of operating and equipment irregularities which may cause "Bell Rang" reports.

For example, the completing operator may complete a connection to a wrong number, recognize her mistake, and correct it. A cutoff may occur before the called station answers. If the calling party signals before the called station answers, the operator may in error take down the cord on which the called station is being rung.

In addition to operating errors, there are some other

conditions that may cause "Bell Rang" reports. When a plant man is working on a line, he may accidentally ring the bell or cause bell taps which are mistaken for a ring. Due to faulty adjustment, the bell may tap when another station on the line is using it. Following a long distance call, the "disconnect ring" of the distant long distance operator may, under certain conditions, be heard by a subscriber who has just finished talking on a long distance call, and by the time he answers, the connection may have been taken down.

As these operating and plant irregularities aggregate less than one case in a thousand, they, of course, have a very small effect individually.

*Irregularities Attributable to the Subscriber*

Of the nine "Bell Rang" reports in a thousand calls, seven are due to the fact that the person who made the call did not wait long enough for the called person to answer the call. In about half the cases, the person making the call disconnected very quickly. In the other half, the person called was a minute or more in answering. Undoubtedly, there are excellent reasons for both conditions, but it is to be noted that seven out of the nine cases are due to this situation.

In addition to the above major cause, there are some minor irregularities. For example, the called subscriber may remove the receiver, thereby stopping the ringing, and then delay his answer. If the answer is not made promptly, the person who made the call may hang up, thus giving the disconnect signal to his operator who takes down the connection. When two or more telephones are near each other, a subscriber sometimes confuses the rings, answers the wrong telephone, and reports that his bell rang. These miscellaneous conditions are minor in their effect. Added to the miscellaneous conditions for which the telephone company is responsible, they total one case in a thousand calls.

*Means of Decreasing "Bell Rang" Reports*

The consideration of this subject would not be complete without some discussion of ways and means for effecting a further improvement.

While less than two of the nine cases of "Bell Rang" reports in a thousand calls are now chargeable to the telephone company, constant effort is being made to realize a further improvement, if possible, as any relaxation of effort would probably mean a substantial increase. Continued efforts are necessarily directed along two main lines: first, to maintain the telephone plant as close to required standards of performance as is practical; second, to secure the highest possible degree of accuracy on the part of the young women who serve as operators. In the first case, this involves particularly all line and supervisory signals, cords, plugs, bells, ringing apparatus, frame connections, subscribers' loops, trunks and all other items of equipment involved in connecting one telephone with another, while the second case involves laying particular emphasis on the handling of numbers, attention to signals and completing connections.

As the subscribers are responsible for seven of the nine cases, there is a broad field here for improvement. It will be remembered that the ringing signal is usually heard a few seconds after the call is given to the operator. After this signal is heard, sufficient time should be allowed for the called station to answer. This interval varies considerably. If the call is to a man seated at his desk in an office, the interval is very short. If the call is to a house or an apartment, a minute or more may elapse. If the call is to an apartment house where the switchboard is attended by an elevator boy, three minutes or more may elapse. The person making the call usually knows the conditions and can gauge the interval.

The "Bell Rang" condition may be further improved if subscribers will answer their telephone calls promptly and will make an immediate response on each incoming

call. If it is not convenient to carry on conversation immediately, it would be well to indicate this to the person making the call. This is particularly important in the case of a private branch exchange operator who has plugged into a line to stop the ringing.

This analysis of the causes of "Bell Rang" reports also indicates that the condition is one that will never be entirely eliminated. With the best maintenance possible, apparatus will occasionally get out of order, and with the best possible training and supervision, operators will occasionally err. The calling party will not always be able to wait until the person called is at liberty to answer. However, if efforts are directed along the lines indicated above, it may be possible to effect some improvement, and, in any event, an understanding of the causes may make the condition a little less objectionable.

K. W. Waterson.

# Long Distance Cable Telephony in Europe

ON January 7, 1927, commercial telephone service was established between the Old and New Worlds. Service was at first limited to London and environs in Europe and to New York and suburbs in the United States, but extensions to all the United States, Cuba and the principal cities of Canada, and to all of Great Britain, all of Germany and eight large cities on the continent, have followed in rapid succession. Today, a resident of the United States can make a call to the 18,500,000 telephone stations in and connected with the Bell System, 1,385,000 telephones in Canada, Cuba and Mexico in the Western Hemisphere, and 1,600,000 telephones in Great Britain, 2,850,000 telephones in Germany, and 666,000 telephones in the eight principal cities of four countries of Europe in the Eastern Hemisphere. By the spanning of the Atlantic with a radio telephone connection, any one of 250,000,000 people, served by 25,000,000 telephones, which is about 80% of the world's telephones, can be reached by a speaker in the United States. To converse between the uttermost parts of this system—San Diego, Cal., and Stockholm, Sweden—requires that the human voice be carried by electricity 8,630 miles. This presents an interesting contrast to the two-mile Boston-to-Cambridge circuit over which Bell and Watson talked in 1876.

The rendering of telephone service on a scale of the present-day magnitude requires the highest type of technical skill and standardization of methods and practices on the one hand, and cooperative endeavor between nations on the other. To interconnect wire telephone systems by radio demands that these wire systems be of the highest order. The construction of high-grade wire circuits in Europe within the last ten years has gone forward most rapidly. These circuits are largely in underground cable. Today, the existing and proposed cable network

for long distance telephone communication in Europe presents an imposing picture.

### Value of International Telephone Service Recognized

At the Brussels Congress of the International Chamber of Commerce in 1925, the following resolution was unanimously adopted:

> "The Congress of the International Chamber of Commerce recognizes the importance of an international telephone service in the promotion of commerce and trade between the nations, and the betterment of international relations."

At the meeting of the same organization in Stockholm, in June, 1927, international telephone service was recognized,

(a) As an effective instrumentality for removing impediments to international trade, and

(b) That the ability to secure speedy personal communication between distant cities should be a factor in stabilizing business through a more orderly and economic movement of goods;

(c) That effective telephone service tends to facilitate all the processes of production and distribution;

(d) That ability to communicate information quickly, tends to minimize the range of price fluctuations and thereby lessen the tendency to speculation;

(e) That any instrumentality which tends to stabilize business, facilitate its processes, and effectively extend the field of operations with consequent increase in the volume of trade, should lessen the difficulties of international settlements, for after all, all settlements have to be made ultimately in goods or services;

(f) That the ability to communicate voice-to-voice, easily and speedily, whenever desired or needed, cannot but be a means of improving social relationships and developing a common economic and social viewpoint which inevitably must have an effect in promoting a better understanding between nations.

The committee on long distance telephony at the Stockholm meeting called attention to the problem of telephone service in Europe as it existed in 1922 as follows:

(a) The construction and improvement of the telephone plants had been at a standstill during the whole of the war period.

(b) About forty self-contained local operating organizations, each also conducting a part of the international telephone service.

(c) No organization controlling or coordinating the various local operating organizations which had to function together in handling international calls.

(d) No organization of any kind which made plans for the international service as a whole.

(e) No common research, standard practice or technique of construction, maintenance or operation.

(f) No common agreement as to manufacture.

### European International Consulting Committee
### Established 1923

Recognizing the need of a central body to consider international requirements, an expert committee on long distance telephony met in 1923 at the direct invitation of France, and inquired into the question of long distance telephony in Europe. This committee made a preliminary study of the situation and recommended the ap-

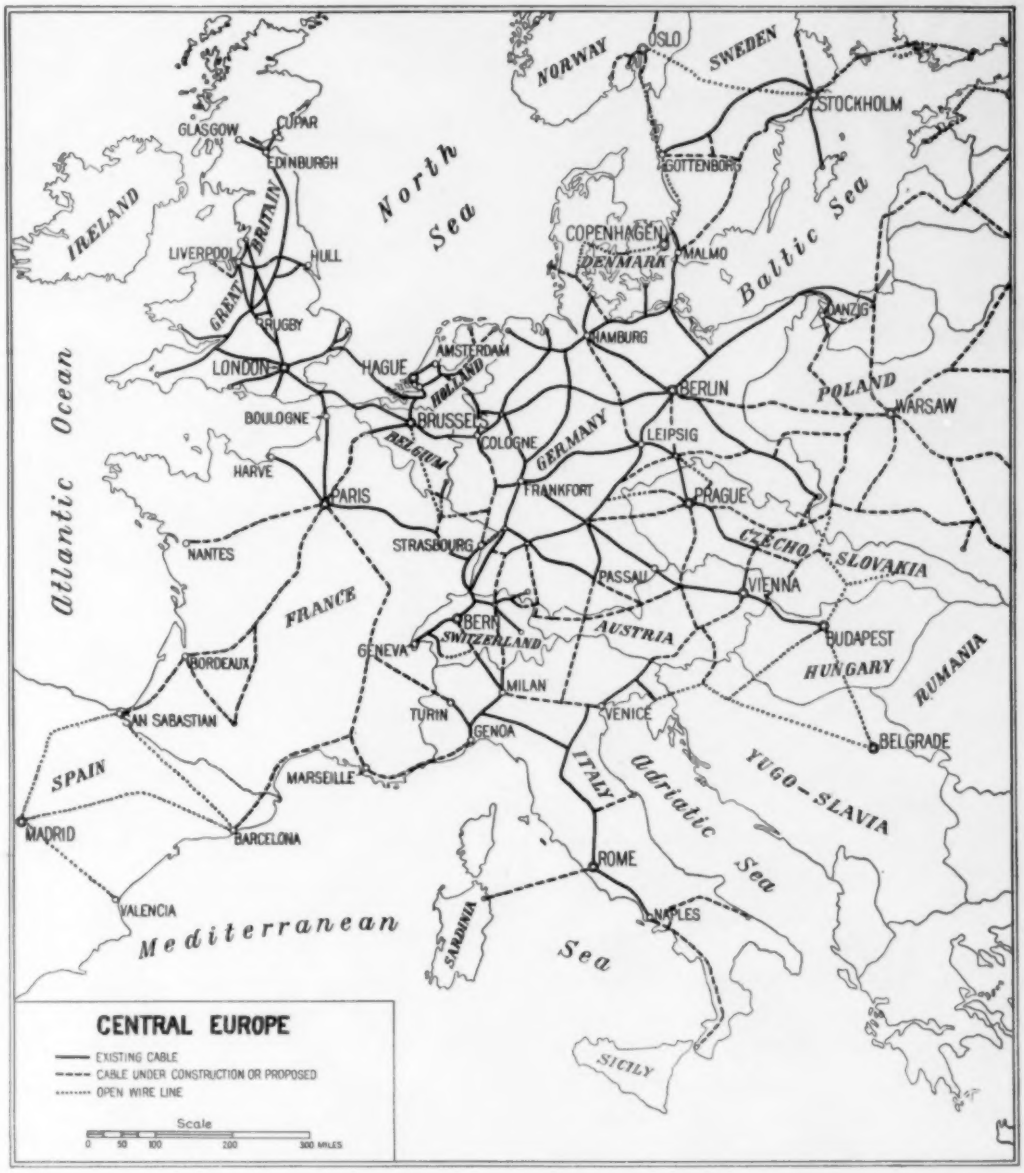
pointment of an International Consulting Committee on Long Distance Telephony to be composed of representatives of all European Telephone Administrations. In April, 1924, this committee was formally established and held its first meeting, representatives from nineteen European countries being present. The efforts of this committee have been far-reaching, not only in the line of establishing reliable standards as a basis for sound technical progress, but also indirectly in stimulating an extended use of modern methods of international communication.

The European Administrations have been quick to take advantage of the improvements in recent years in long distance telephone cable systems. The advances made in the loading of cables, the development of the vacuum tube repeater and refinements in the design of telephone cables, have with the rapidly growing demand for circuit facilities all combined to produce a secure and economic means of providing long distance transmission over distances which formerly could be bridged only by open wires. The vacuum tube repeater particularly made possible the introduction of small gauge cable conductors for long distance use, thereby enabling a very large number of communication circuits to be carried safely in the relatively small space afforded within the cable sheath. The European countries which so far have extended the long distance telephone systems in cable are Austria, Belgium, Czecho-Slovakia, France, Germany, Great Britain, Holland, Hungary, Italy, Sweden and Switzerland.

## Long Distance Telephone Cable Facilities

### *Austria*

Austria's geographical position in the heart of Europe gives it a key position in providing transit facilities for international telephone traffic. On January 4, 1927, the first long distance cable was completed between Vienna and Passau near the German border. This cable is 170




NETWORK OF EUROPEAN LONG DISTANCE TELEPHONE CABLES

miles long and contains a total of 114 circuits of various types. The connection by cable with Hungary is also completed and in a few months it is expected that another cable starting from Linz, located on the Vienna-Passau line, will extend south to the Swiss border.

The entire Austrian long distance cable network consists of over 497 miles of cable, supplying 49,000 pair-miles of circuits. When the cables now projected have been installed, Austria will have nearly 1,242 miles of toll cable facilities.

### *Belgium*

Belgium is territorially one of the smallest countries in Europe and had, in 1921, a total of 280,000 miles of telephone wires in use. By 1925, this figure had risen to 500,000. In other words, the telephone wire mileage increased nearly two-fold in a five year period. As early as June, 1903, the need for telephone communication between London and Brussels was filled by means of a submarine cable from St. Margaret's Bay to La Panne. In 1911, the second cable between the same points was laid and early in 1927, a third cable, providing 21 circuits, was put in service. The first cable section to provide direct traffic within Belgium itself was that between Brussels, Bruges and La Panne on the west border, a distance of 94 miles. Extending eastward from Brussels through Liege to Hergenrath, a cable connects the Belgium long distance telephone system with Germany. This was completed in January, 1927. Liege is an important industrial center sixty miles from Brussels and originates a large volume of telephone traffic with the capital. Provision for adequate international circuits to Holland and France were made by two main cables, one going north from Brussels via Antwerp to Roosendaal, a distance of 55 miles, and the other going southwest to Lille, a distance of 65 miles. At the present time, the cable toll network of Belgium consists of 590 miles of large-size telephone and telegraph cables.

### *Czecho-Slovakia*

Czecho-Slovakia, the newly restored republic in Central Europe, early recognized the need for complete modernization of its long distance telephone system, in order to link up the various towns in its domain with Prague, its capital, and also to keep abreast of the development of international service. The main system of cables now installed and under construction represents an aggregate of about 305 miles of cable fitting into the general plan of development which calls for building of cables in six radial directions from the capital city.

### *France*

Unique circumstances characterized the building of the first long distance telephone cable in France. Shortly after the Armistice and the restoration of Alsace and Lorraine to the French republic, it was realized that greatly improved communications were needed between these provinces and Paris. Work on the Paris-Strasbourg cable was begun in October, 1923. It was opened for service in April, 1926, and but for short distances, contains a total of 82 quads for telephone circuits, designed for two-wire and four-wire operation. The cable also contains 12 telegraph quads. It is 308 miles long. The German long distance cable system which reaches the French border not far from Strasbourg, is now linked up with this cable. A thorough cable circuit is in operation from Paris and Berlin via Karlsruhe, Frankfurt and Leipzig, employing 14 amplifying stations over a distance of 832 miles. With the completion of the Vienna-Passau cable early in 1927, an all-cable circuit from Vienna to Paris was established via Strasbourg. Two more branches in the main cable network have been completed, namely, the Paris-Havre and the Paris-Boulogne. The former is 130 miles long and for the present is a link in the French National System, since no submarine cable connection from Havre to Great Britain is at the present time foreseen. The

Paris-Boulogne cable which is 158 miles in length, is primarily intended to form the main connecting subsequent link between the French and British telephone systems. The completion and putting into service of this cable on March 1, 1928, made possible service between New York and Paris via radio to Cupar, Scotland, and London on March 28. Previously, the various submarine cables across the English Channel have been connected to the French open wire lines converging on Paris. The concentration of all routes into the Paris-Boulogne cable marks a great step forward and will enable a more extensive and more rapid service to be given, not only on the Paris-London circuit, but also for transit traffic which will be routed over the new cable. In March, 1927, a new paper insulated submarine cable of 21 circuits was laid between Sandgate, England, and Boulogne. Work on the Paris-Lyons cable in South France, a distance of 310 miles, was begun in 1927. At present there is something over 738 miles of long distance cable operating in France. A total of about 370 miles is under construction.

### *Germany*

Germany has introduced cables in its long distance telephone system at a rapid rate. In 1920, there was something like 185 miles of long distance cable in service. By February, 1927, there were 4,595 miles of long distance cable installed. It extends over the whole country and links practically every town of importance.

In 1925, the connection with Switzerland was established by completing cable sections from Frankfurt via Karlsruhe to Basel. In 1926, cable connection was realized between the German system and France by joining the Paris-Strasbourg cable which was completed the same year. An all-cable route to Holland was also brought about in 1926. This cable to Holland permitted a very much desired all-cable circuit to Great Britain which for some time prior to this achievement had been con-

nected by direct cable with Holland. The Berlin-London cable circuit via Holland was put in commercial service in March, 1926. The total length of this connection is about 860 miles and is the longest through cable circuit in commercial use in Europe today.

Although the major part of Germany's international traffic is concentrated over land routes, Germany is in large measure dependent on sea routes for its connection with the Scandinavian countries. The aggregate length of submarine cables reaching out from Germany is about 750 miles.

### *Great Britain*

Great Britain is a densely populated country in its more important commercial and industrial centers, scattered over relatively small areas, and the need for an adequate national long distance telephone system is self-evident. Before the advent of the long distance cable, Great Britain possessed a backbone system of well-maintained open wire telephone and telegraph lines, covering practically the entire country. Great Britain was a pioneer in the use of long toll cables. At first they were the large sized wire, non-loaded type. Large wire, loaded cables were installed before the war and before telephone repeaters came to be used. The present long distance cable system which today supplies the nation's need for telephone service follows, in general, the routes which were formerly served by the open wire lines. From London, four main arterial cables emanate, namely: London to Glásgow via Leeds, Newcastle and Edinburgh; London to Manchester and Liverpool; London to South Wales via Reading and Bristol, and London to Portsmouth and South Hampton. London is also the main center for international telephone service. Forty miles north of Edinburgh is Cupar where the trans-atlantic radio telephone receiving station for service with American is located. The wire connection to London is

made via the first named arterial cable with eight repeater stations en route.

The longest cable connection in Great Britain is that between Plymouth and Glasgow, a distance of 563 miles. In 1927, the combined length of all the long line cables was 6,240 miles with 625,000 pair-miles of circuit. The main cables in this system average about 137 pairs of conductors.

Cables designed especially for connection within the continent run directly to towns on the eastern south coast where a large number of submarine cables extend to various ports in Holland, Belgium and France. The latest development in these cables, as far as Great Britain is concerned, is that of the 7-quad submarine cable which gives 21 high-grade circuits. Cables of this type have been laid to France and Belgium. Submarine telephone cables from Great Britain aggregate 770 miles.

In connection with the international traffic, it is of interest to note that regular telephone service with Germany via Holland was opened in the autumn of 1926. Commercial service with Holland has existed since 1922, at the time the first Anglo-Dutch cable was laid. In June, 1927, regular traffic was inaugurated between London and Stockholm. Except for about 252 miles of open wire lines in Sweden, this circuit is 1,490 miles long and is in cable.

### *Holland*

Holland's telephone development has been rapid. In 1904–14, the telephones per hundred population increased three-fold. In 1914–24, this ratio was doubled. Furthermore, one-half of the telephones in Holland are to be found in the three largest cities, Amsterdam, Rotterdam and The Hague.

In 1911, it became evident that telephone traffic, especially between the three largest cities, was growing at such a rate that the open wire lines could no longer provide the desired circuit facilities. The Administration,

therefore, decided that underground cable to interconnect these cities should be laid and they at once proceeded with the construction of ducts and manholes. The actual cable installation was stopped with the outbreak of the war. It was not until 1919 that the laying of the cable began. Opened for service in September, 1921 it provided a total of 180 loaded circuits designed for two-wire operation and is 57 miles long. In 1921–22, the Amsterdam-Utrecht (26 miles) cable, providing 128 loaded circuits, was installed. In 1922, the branch of the Dutch cable system which now forms part of an all-cable telephone communication system with Great Britain was begun. These all-cable circuits between Holland and Great Britain also carry the transit traffic between the latter country and Germany, the London-Berlin line being put into commercial service in the fall of 1926. In 1925–26, big strides were made in extending the Dutch long distance cable network. Additional cables were installed on the Amsterdam-Utrecht and the Amsterdam-Rotterdam connections. A new direct cable from The Hague to Utrecht (46 miles) was laid and extended eastwards to Arnhem on the German frontier. In this manner, direct international cable routes were established between the three main cities in Holland and the German national system. A short cable between Roosendaal to Esschen on the Belgium frontier was scheduled for completion in 1927.

The national long distance telephone system in Holland now contains a total of 885 miles, in which figure is included one-half of the Anglo-Dutch submarine cables. This cable system represents an aggregate of about 86,600 pair-miles of loaded circuits.

### *Hungary*

Hungary has recently been linked by cable with the European long distance network. A loaded cable with repeaters 98 miles in length has been laid between Buda-

pest and Vienna, the Hungarian portion terminating at Halbturn. This is the first long distance cable in Hungary and is designed for international working, containing high-grade two-wire and four-wire circuits in sufficient numbers to give adequate service. Future plans for the provision of long distance facilities call for two main cables, one in southeast and southwest. The former will reach Yugo-Slavia and the latter will eventually extend to Belgrade.

### *Italy*

Italy initiated plans to connect the more important industrial centers in Northern Italy, Lombardy, Piedmont and Liguria, by a loaded telephone cable system in 1912.

In March, 1913, the Italian parliament passed a law authorizing the Ministry of Posts and Telegraphs to undertake the laying of the projected cables. The outbreak of the war suspended these activities.

In 1919, the project was revised and re-examined in the light of the latest developments in long distance cable telephony. By that time a new factor entered into the problem, namely, that of safeguarding the cable circuits against high tension interference. The hydro-electric development in Northern Italy had reached a stage unequalled in most European countries. An exhaustive investigation was carried out in 1920 and suitable cable routes were selected which insured immunity from disturbances from the high tension lines. In 1921, the first long distance cable system in Italy was begun. It took the form of a Y, with the three cities of Milan, Turin and Genoa at the extremes and a repeater station in the center, representing a total of 184 miles of cable with a pair length of 14,000 miles. It was opened for commercial service in 1924. Traffic between the three cities doubled in a short time.

The additions to the all-Italy cable system now being carried out will bring together, telephonically, all the

cities in Northern Italy as far east as Trieste, and will extend south as far as Naples. The Island of Sardinia will be connected with the mainland by means of a submarine telephone cable. It is estimated that the projected cable system, aggregating 1,365 miles, will be completed in 1931.

From the standpoint of international service, it is evident from the very nature of the geographical position of Italy that the main cities for international telephone traffic will enter over the northern boundaries of the country. While at the present time no direct cable connections have been made across the border, the various routes over which this traffic will be carried are fairly well defined. From Switzerland, two main routes will converge upon Milan, one from the west through the Simplon tunnel and one from the north to the St. Gothard tunnel, entering at Chiasso.

### *Sweden*

Sweden's high telephone development is in no small measure due to the provision of efficient long distance service to all points of the Kingdom. Territorially speaking, Sweden is one of the largest countries in Europe. The greatest density of population, however, is to be found in middle and southern Sweden. The two largest cities in the Kingdom, Stockholm, the capital on the east coast, and Gothenburg, the most important commercial city on the west coast, were in greatest need of improved telephone communication. Plans for a cable system to connect these two towns were completed in 1920. Early in 1923, the cable was put in service. It is 335 miles in length and the total length of circuits, physical and phantom, amount to 55,700 miles.

A cable 108 miles in length extends directly south from Stockholm and will form a part of an all-cable system via Malmo to the German and Danish systems. By this connection, Central and Southern Europe will be reached.

Another important cable which is nearing completion extends north from Stockholm to Upsala.

The Swedish Telegraph Administration owns and operates jointly with the Danish and German authorities certain submarine telephone cables. Including one-half of the combined length of these submarine cables, there are today 653 miles of toll cable in Sweden. Plans now call for the addition of 1,180 miles.

### *Switzerland*

Switzerland, owing to its central location, occupies an important position in regard to international communication. Even before modern long distance cable came into use, several international lines traversed the country, and it has been generally recognized that for transit traffic, the Swiss have always been ready to assign some of their best circuits. The first international telephone lines were established in Switzerland in 1897. In 1900, regular telephone service was inaugurated between Basel and Berlin, and ten years later 67 international circuits maintained traffic with Austria, France, Germany and Italy. Telephone traffic with Great Britain was opened in 1914 and also in that year the first transit service was given by the assignment of open wire line circuits for the Berlin-Milan connection. In connection with its growing need for more telephone lines, Switzerland has continually been faced with the problem of guarding its communication circuits against interference from electric power and electric railway circuits.

The Swiss long distance telephone cable system was begun in 1921, when specifications were drawn for a cable from Lucerne to Attinghausen (32 miles). From this modest beginning, the Swiss long distance cable network has grown steadily, and today, upwards of 1,055 miles of cable, containing approximately 60,000 pair-miles of circuit, connect the more important sections of the country. Broadly speaking, the cable system consists of two main

arterial routes, one running northeast from Geneve via Zurich to St. Gallen near South Germany, and the other running almost due south from Zurich through the St. Gothard tunnel to Chiasso on the north Italian frontier. These two main line cable routes are designed to carry international telephone traffic that comes from Belgium, France and Great Britain via Basel from Germany, Holland and Scandinavia via Basel and Schaffhausen, from Austria-Hungary and the Balkan States via St. Gallen, and from Italy to Chiasso. Two separate cables parallel one another over practically all the main routes. One of the cables is intended for long haul traffic within the country as well as for international service, and is known as the main cable (principal). The other cable is provided to take care of intermediate traffic and telegraph service. It is a sort of omnibus cable which collects traffic at intermediate points.

A study of the rugged and mountainous terrain of Switzerland reveals an interesting aspect of its long distance cable system. The cable routes generally follow the valleys, traversing in their course the more densely populated areas of the republic. The key city in the cable network is Zurich, commercial metropolis of Switzerland, which, so far as telephonic communications are concerned, may be regarded as the clearing house for the international traffic.

Geneva, the seat of the League of Nations, is at present provided with facilities for communication with Italy via Lausanne, Martigny and Brig. Cable service from Geneva to North Europe and Great Britain is routed through Lausanne and Basel.

## Summary

Although the number of international circuits carried entirely in cables is at the present moment somewhat restricted, some striking examples have recently been accomplished in this regard. There are all-cable circuits

between the entire national cable system of Great Britain, Belgium, Holland and Germany, apart from cable connection between contiguous countries. Adding together the lengths of cable installed in eleven countries forming a part of the existing long distance cable system in Europe, there is an aggregate of 15,150 miles, providing 1,692,800 miles of cable pairs. The longest direct cable circuit in operation on July 1, 1927, was the Berlin-London circuit, 860 miles in length, and equipped with 15 telephone repeaters. The gaps in the European cable system at present bridged by open wire lines are rapidly being filled with cable. International telephone traffic will eventually be handled over an extensive underground and submarine cable network which will insure rapid and high-grade communication by the spoken word between the nations of Europe.

J. O. PERRINE.

# Regional Trends and Shifts in Industry

IN an article in the April, 1928, issue of this QUARTERLY, on "Measures of Regional Business Activity," it was stated that "the telephone business, while of an unusually stable character, is to some degree at least affected by changes in economic conditions and fluctuations in industrial activity as exemplified by the cyclical movements of a general business index." It was the recognition of this fact that prompted the compilation of indexes of general business not only for the nation as a whole but also for each of the Associated Company operating areas. In each of these curves the element of long time growth or trend has been statistically calculated and eliminated, so that the resulting curves reflect short time swings above and below a trend line or "normal." There are times, however, when in the study of economic activities the emphasis is not on the short time fluctuations. The longer the period of time for which a forecast of telephone growth and performance must be made, the less, naturally, is the importance of the immediate economic outlook. In such cases it is the trend or growth itself of the more important types of economic activity within the territory of the telephone company, which is of principal interest, rather than the current position with regard to the calculated trend.

This is especially the case where there is pretty clear evidence that the trends or the rates of growth in these key industries are being modified. Factors influencing or modifying the trend or rates of growth may arise either from within or from without a certain territory. Only in rare cases is a given territory or an industry within the territory an economic entity. The opening-up of new sources of production or new industries, and changing relationships between existing regions, give rise to constant shifts in important industries and other economic activities from one territory to another or even within a single territory, which may be and frequently are of consider-

able importance to future telephone growth and business. It is the purpose of this article to point out a few conspicuous examples of major shifts in certain important agricultural and extractive industries. A second article will add some additional examples, taken from the fields of mineral production and of manufacture.

However complete a survey of population, resources and activities of a given region may be, it is at best an incomplete basis on which to judge the future, owing to this fact of interterritorial influences. Where a territory is serving a distant market and competing with other territories for that market, changes in the consuming districts, and the relative advantage or disadvantage as compared with other areas, will often be greater determinants of future trends and rates of growth than population changes. Surveys of factors arising from within a territory such as increase in population, natural resources and transportation facilities, are, it is true, absolutely necessary, but they must be supplemented by a study of outside economic influences which may affect the territory. On the basis of a survey it may be found, for instance, that a region may have the soil and weather conditions suitable for the successful and profitable growing of wheat, but on the other hand it may be, or may come to be, still more profitable to leave the growing of wheat to another territory and to turn to the production of another product, such as corn. The opening up of new mines in another region may affect the prosperity and future growth of mines in the territory under survey, even though the latter are far from exhaustion.

There are numerous factors which affect the location and distribution of economic activities and determine relative rates of growth. These factors operating in a given region may stimulate a greater rate of growth than in surrounding areas; they may retard growth or even, as will be brought out later, may operate to bring about an actual decline. An important factor, especially in the case of extractive industries and those whose raw ma-

terials are subject to depletion, is the abundance and availability of natural resources. The future of industries utilizing these resources depends, however, to a considerable extent on the state of resources in competing regions. Ores that may be commercially valuable at one time may cease to be so as the result of the opening of newer mines with lower costs. The quantity or quality of raw materials is, however, only one factor in determining the question of lower or higher costs. The problem of transportation is often of considerable importance and the relation of the producing district to the consuming centers may be a deciding factor. The decline in the importance of the blast furnace industry on the eastern seaboard is, in part at least, the result both of relatively high transportation costs on ore and coal and of the shift of the consuming market westward. These producers, with their old high-cost equipment and heavy transportation expense, can at best hope to retain only certain of their eastern markets where they are at less of a disadvantage. (The shifts in the iron industry have been comprehensively studied by H. B. Vanderblue and W. L. Crum in their book, "The Iron Industry in Prosperity and Depression.")

The quality and money cost of labor is another important factor determining the location of industry. This it is which militates against the successful operation in the United States of many activities which require an abundant supply of very cheap unskilled labor. The higher wage levels necessitate the use of labor only in activities where the productivity per worker is relatively high. It is for this reason that machine rather than hand industries predominate in this country.

An important factor affecting the future growth of an industry is the competition between industries not only in the consuming markets but for productive localities. The rise of the rayon industry as a competitor of the earlier established textile industries illustrates the former, and the displacement of wheat growing by corn in certain middle western states is an example of the latter.

The factors mentioned above are merely illustrative and are by no means an exhaustive list of the numerous influences both within and without a given territory or industry which determine the location of economic activities. The varying importance of such factors, and their constantly changing effects on the industrial structure, give rise to the so-called regional shifts of industry. In this connection statistical analysis of past and present trends is a valuable aid in determining the extent and progress of such shifts as may be found to be under way.

The examples of shifting economic activity which are discussed below are taken from coal mining, the lumber industry, cotton growing, and wheat and corn growing. In each case, statistics in chart form are presented for a considerable period of years, showing the development of the industry in those two or more territories of Associated Companies of the Bell System which are responsible for the major part of the country's output. For each territory on each chart, trends have been statistically computed and indicated for the various series; and thus the changing relative importance of the various territories, and the shifts in trends or in rates of growth within individual territories, are clearly brought out. While it is true that statistical analysis can only measure the rate and direction of a given change as revealed by existing data, and can not give an infallible indication of future change, nevertheless such analysis, in measuring and clarifying changes as they have already exhibited themselves in economic series of data, will give a sound basis for further study into the probable causes of such changes and the likelihood of their continued influence on the economic structure of the territory under consideration.

## Shifts in the Coal Industry

The continuance of the strike in the bituminous coal fields during the past year has done much to emphasize the difficulties under which this industry has been oper-

ating. Most of these difficulties may be traced back to the factor of an excessively developed capacity. Productive capacity in the industry is such that if all existing coal mines in the United States today were to be operated on a full time basis the result would be a production far in excess of any possible consumptive demand from within the country. This over-capacity results in part from increased efficiency in the consumption of coal and partly from the use of substitute fuels, both of which have slowed up the growth of the nation's coal requirements, with the result that consumption has not kept pace with the growth in productive capacity. Then also there is the fact that from time to time in the past, labor difficulties in the older established fields as well as transportation tie-ups have interrupted the flow of production and have for short periods considerably increased the price of coal. This has encouraged the development of new mines which, when the emergencies which brought them into being were over, continued in the industry as potential demoralizing factors. The resulting keen competition and low prices, especially during the past several years, have emphasized and accelerated shifts in the production of coal from the so-called central competitive fields—in the territories of The Bell Telephone Co. of Pennsylvania and the Ohio, Indiana, and Illinois Bell companies,—to the territories of the Chesapeake and Potomac and the Southern Bell companies. The marked decline in the rate of growth of production in certain of the older fields had begun to make itself apparent even prior to the coal strike of 1922 and the Jacksonville wage agreement of 1924.

Chart 1 shows output, from 1895 to date, in each of the more important coal producing territories. As brought out by the data and by the trends shown, production in all four regions was increasing rapidly—though at different rates of growth—up to within a short time before the war. At about that time production in Pennsylvania ceased expanding and has since shown no sustained trend

either upward or downward. Production in Ohio, Indiana and Illinois, as indicated by the trend, continued to expand during the war but in recent years has exhibited a sagging tendency. The Chesapeake & Potomac and Southern Bell territories, on the other hand, have consistently maintained high rates of growth. These rates

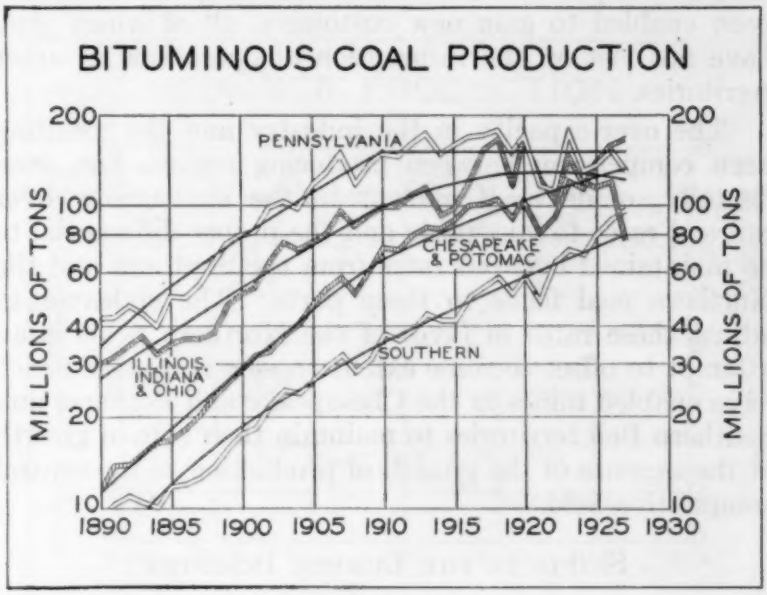



CHART 1

of growth, related, as they are, to constantly increasing totals, indicate a tendency to greater absolute gains year by year.

The more consistent and greater rate of growth in the latter two territories is due in part to the fact that in these regions are many of the newer mines which not only have an advantage in the quality of coal veins and the greater facility of mining, but in many cases are better equipped mechanically for the economical production of coal. The fact, furthermore, that workers at these mines are non-union has made it possible for coal operators to obtain labor at wages less than standard

union scales. Moreover, these mines have benefitted from the fact that in the past they have been a steadier source of supply than those fields which have been beset with labor difficulties. Consequently at the time of such stoppages as occurred in Ohio in 1914, in all union (and some non-union) mines in 1922, and in the union mines during the past year, these non-union producers have been enabled to gain new customers, all of which they have not lost on the resumption of operations in other territories.

The over-capacity in the industry and the resulting keen competition between producing regions has, incidentally, made itself evident in the controversy over railroad rates to lake ports and the proper differential to be maintained between rates from the Southern and the Northern coal fields to these ports. The endeavor to adjust these rates in favor of the Northern fields is an attempt to offset to some extent those advantages which have enabled mines in the Chesapeake and Potomac and Southern Bell territories to maintain their rate of growth at the expense of the growth of production in the central competitive field.

### Shifts in the Lumber Industry

At one time forest land in this country amounted to over 40% of the total land area of the nation, but by 1920 this had been reduced to about only 25%. Lumbering has always been primarily, from its very nature, a frontier industry and as the country's frontier has moved westward and southward, logging and allied activities have preceded it. Writers on our economic and social history, however, put the end of the American frontier in the nineties, and yet Chart 2 shows important changes that have taken place just in the past twenty-odd years. Chart 2 is based on figures compiled by the United States Department of Agriculture, for three selected regions from 1904 through 1926. The decline of output in the lake

states, Michigan and Wisconsin, shown on this chart, and the rapid expansion, at an annual rate of about 4%, of production in the west coast area, a territory roughly approximating that of The Pacific Telephone and Telegraph Company, clearly indicates the continued westward movement of the industry. It is interesting to note moreover that the decline in production in recent years,

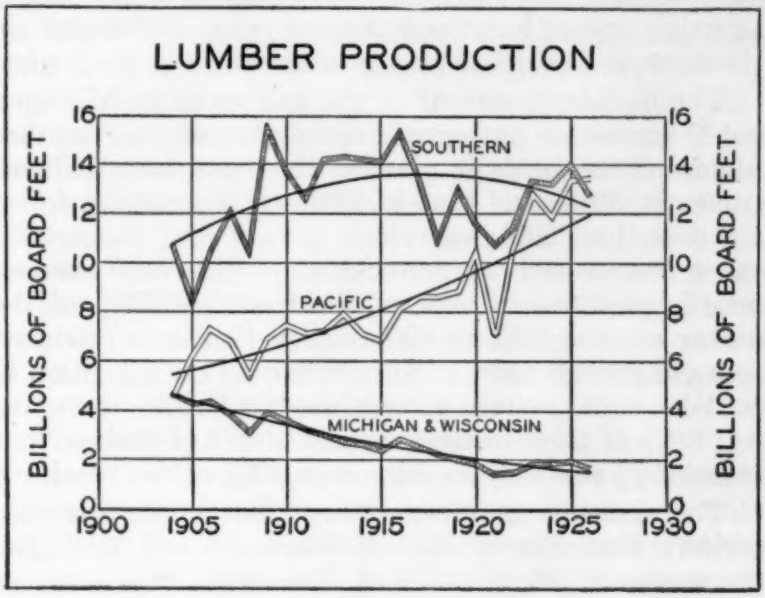



CHART 2

shown for the territory of the Southern Bell Telephone and Telegraph Company, is due in large part to a reduction in the lumber output of the three northernmost states of the territory, whereas the other states taken as a unit have, in fact, continued to advance and in 1925 made a high record for the period under review.

The lumber output of the country as a whole reached its peak in 1909 and since then has shown a tendency to decline rather than to grow. Consequently the opening up and exploitation of the softwood forests on the Pacific coast has been at the expense of other regions such as the

Michigan-Wisconsin area. The decline in production in these latter two states is due almost entirely to reductions in the output of softwoods. The production of hardwood, which has not had to meet competition from the west coast territory, has been well sustained. The hardwood industry also has been favored by the fact that Michigan, because of the importance of the furniture industry, consumes more hardwood than is produced in that state. Actually, more hardwood lumber was distributed in Michigan in 1926 than in any other state in the Union.

The decline in output of the soft wood in Michigan and Wisconsin is not surprising in view of the fact that original forest lands in those states have been reduced by nearly 50%, and that in 1920, of the existing forest land less than 20% was virgin growth and about 35% was reported as "not restocking." This fact assumes more importance in view of the fact that 75% of the lumber cut and 90% of high-quality lumber is produced from old growth timber. In contrast to the condition in the lake states, virgin growth on the Pacific coast was over 60% of total forest area and area reported as "not restocking" was only slightly over 10% of the total.

The situation in the northern part of the Southern territory is similar to that in Wisconsin and Michigan. The states of Kentucky and Tennessee, important as hardwood producers, have lost considerable ground to Mississippi, Louisiana and Alabama during the last fifteen years. These latter states are, however, more important as producers of softwoods. Although production of softwoods in these states is considerably greater in proportion to standing timber than in the Pacific area, the effect of competition from the latter area has not as yet produced results similar to those in Michigan and Wisconsin.

### Shifts in Cotton Growing

The advent and spread of the cotton boll weevil has been an important factor in determining the location of

cotton growing. Prior to the spread of boll weevil infection since the beginning of the century, Louisiana and the southern parts of Mississippi and Alabama were the heaviest producers of cotton. With the spread of the boll weevil, however, which became particularly destructive in these states and generally along the Gulf coast, much cotton growing has moved westward and, in the case of the finer qualities, northward. The long staple Sea Island cotton grown in Georgia and Florida has been particularly subject to ravages of the boll weevil, owing to its relatively late maturity. The greater humidity and heavier rainfall of the lower Mississippi Valley and along the Gulf coast in the territory of the Southern Bell Company is more favorable to the development of the boll weevil than are climatic conditions in the Southwestern Bell territory. In fact, the dryness of certain sections of the latter, such as the Texas Staked Plains area, while in some respects disadvantageous to cotton growing, has so far rendered the boll weevil comparatively harmless in those areas.

The spread of boll weevil infection during the past fifteen years has been largely toward the northern and eastern sections of the Southern Bell territory, which were only slightly or not at all infected at the beginning of the century. Loss from boll weevil infection in the years following the war has been pretty heavy in this territory and especially so in Georgia and South Carolina, which previous to this period had been only slightly affected.

The effect of boll weevil infection and of other factors on the distribution of cotton growing is evident from Chart 3. The size of the cotton crop in the territory of the Southwestern Bell Telephone Company shows a gradual upward growth while in the Southern Bell territory, which has been more affected by the more recent extensions of boll weevil infection, the trend is slightly downward. As a result of this shift, the Southern Bell territory, which once produced 60% of the country's raw cotton, now produces less than 50%.

Other less important factors affecting the westward shift in cotton growing are the availability of land and climatic and soil conditions which favor the Southwestern Bell territory. Vast areas of cheap land in this region, formerly thought suitable only for stock raising, have proved capable of producing cheap cotton. Another important advantage, though not permanent, is the

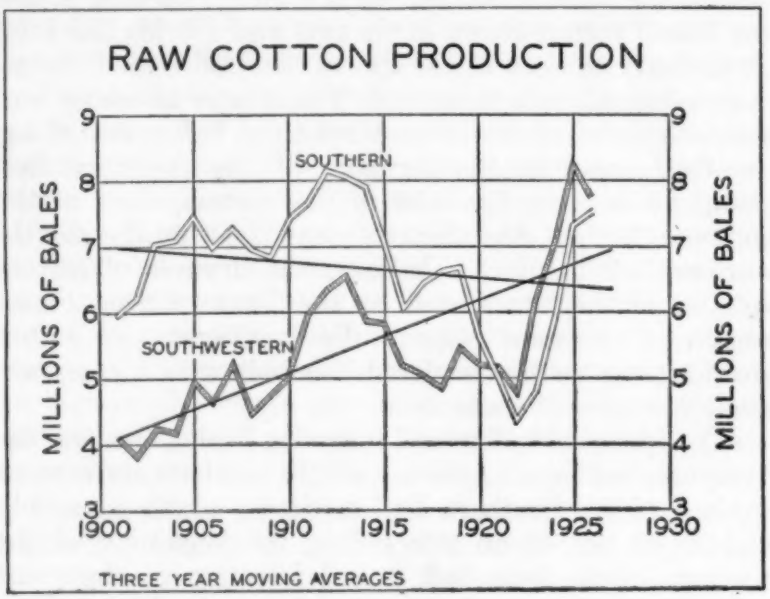



CHART 3

greater fertility of the soil, which has largely obviated the necessity of using fertilizers. In 1927 nearly 75% of the acreage of cotton in the Southern Bell territory was fertilized, principally because of soil exhaustion over a long period of years, whereas the corresponding figure was only about 6% in the Southwestern Bell territory.

There is an additional factor, that of labor supply, which, however, has affected both regions and accordingly has not contributed materially to the westward shift in cotton growing. The picking of cotton requires an abundance of cheap labor. To an increasing extent the labor

factor has been tending to restrict rapid expansion of production in both the Southern Bell and Southwestern Bell territories, though in the latter the use of mechanical picking devices has recently been steadily gaining headway.

### Shifts in Corn and Wheat Growing

Corn and wheat, the two most important grain crops of the United States, dominate agricultural activity throughout a large part of the Southwestern Bell and Northwestern Bell territories. There have been pronounced shifts in the distribution of these two crops. One of the most striking of these shifts is the change from wheat to corn production in Iowa and Minnesota. As may be seen from the upper half of Chart 4, wheat production in these states started downward just after the beginning of the century. The downward movement has become more pronounced in recent years. On the other hand, corn production, shown on the bottom half of the chart, started definitely upward at about the time wheat production turned downward, and has since nearly doubled in amount.

There is a number of factors which favors the production of corn as opposed to wheat in these two states. The temperature and moisture conditions are especially favorable to corn growing. Various factors, including the smaller size of farms, make it difficult to "mechanize" the production of wheat on a large scale, as is done in the sub-humid regions of the Southwestern Bell territory and parts of the Dakotas and Nebraska. The relative yields of corn and wheat are more favorable to corn production in Iowa and Minnesota than in either of these two latter regions.

The consequent expansion of corn production in Iowa and Minnesota has resulted in a westward drift of the hog industry from the eastern half of the corn belt and from Kansas and Oklahoma. The hog industry follows corn growing because of the importance of that grain as

a fodder. The westward shift of the hog industry is not so much the result of changes in corn production in Ohio, Indiana and Illinois, which comprise the eastern half of the corn belt,—although a slight decline is evident

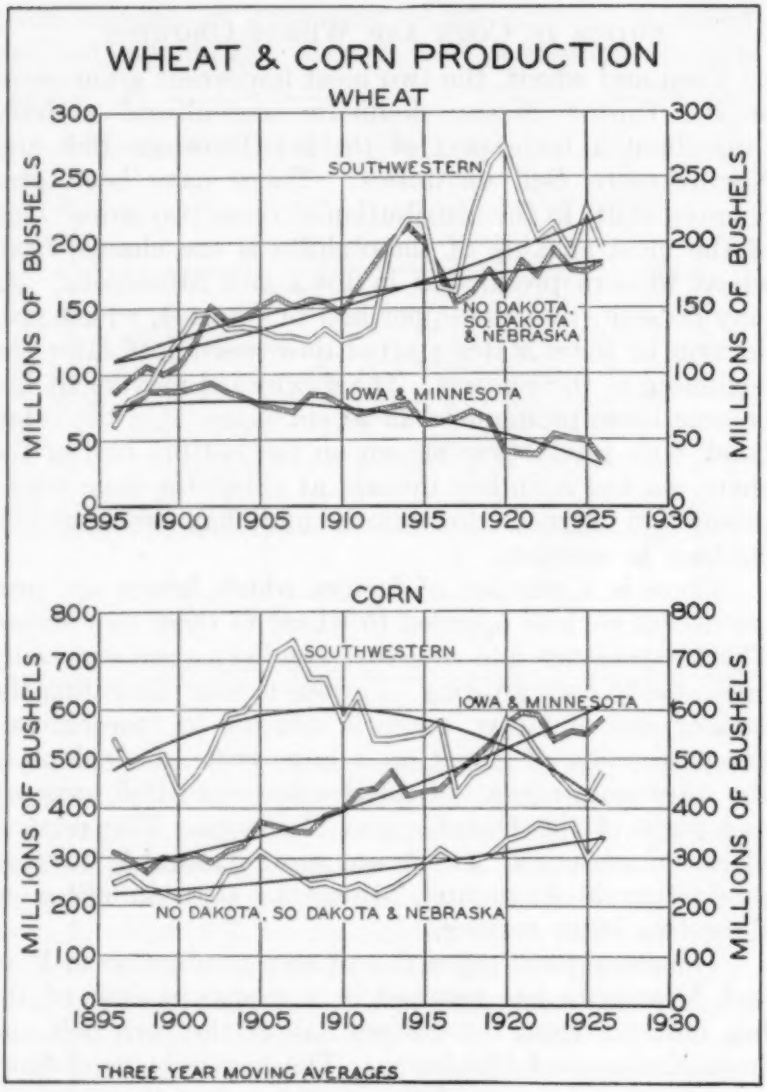



CHART 4

there,—as it is the result of increased market demand for corn. This is due to the proximity of the Chicago market for the grain.

On the other hand, hog raising has declined in Kansas and Oklahoma because of reduced corn acreage in the Southwestern Bell territory. As may be seen in the lower half of Chart 4, there has been a marked decline in corn production in this territory during the past twenty years. Wheat growing, on the other hand, has shown a rapid growth, especially at the time of the war, when war-time prices of wheat caused it to supplant corn. The expansion of wheat production in this territory has accounted for a large part of the expansion in the wheat crop of the United States since the beginning of the century. Wheat yields in the sub-humid regions of this territory on the whole have been more dependable than those of corn. The larger size of farms and the less diversified system of agriculture have made it possible to mechanize wheat farming in this territory to a greater extent than in most other regions. Although wheat yields per acre are lower than in the corn belt, the ratio to corn yields is more favorable to wheat production than in the latter region.

Production of wheat in the Dakotas and Nebraska offers an interesting contrast to production in the Southwestern Bell territory. Prior to the war, production in the latter tended to lag behind, with regard to total volume. Since then production, as may be seen from the chart, has gone ahead rapidly, whereas growth in the Dakotas and Nebraska has become more gradual. In the eastern part of the Dakotas and Nebraska conditions are very similar to those in Iowa and Minnesota. Farmers have turned from the production of wheat to dairying, livestock raising, and corn growing. It will be noticed from the chart, however, that production of corn in the region as a whole has expanded much more slowly than in Iowa and Minnesota.

Land suitable for wheat growing is found on the

Pacific Coast where production of wheat has showed a steady upward growth. However, this growth is not uniform throughout the territory, since there has been a marked shift of production northward. The state of Washington has shown a rapid rate of increase, whereas California has shown a considerable decline. It frequently happens that the apparent trend in the production of a commodity in a given Associated Company territory is the net result of highly different and divergent trends in the several sections of that territory. These intra-territorial shifts have an important bearing on the economic structure of a given region and often are as important in studying the effects of changes in economic activities as are shifts from one territory to another.

As was indicated early in this article, it was the purpose of the article "to point out a few conspicuous examples of major shifts in certain important agricultural and extractive industries," as between the territories of various Associated Companies of the Bell System. In short, what has been written has been illustrative in character. There has been no thought of the material being exhaustive, either as regards the examples that might have been cited, or as regards the economic forces which have been mentioned from time to time as causing the interregional shifts. It is expected in a second article to indicate other examples both in raw material industries and in manufacturing industries. Together, the two articles will, it is hoped, show clearly the importance of the study of fundamental trends in individual key industries, as a supplement to, or supplemented by those studies of short-term fluctuations in general business and in specific industries which form the basis of the article on "Measures of Regional Business Activity," in the April, 1928, issue of this QUARTERLY.

WILLIAM M. LARRABEE.

EDITOR'S NOTE: Mr. Larrabee is of the Chief Statistician's Division of the American Telephone and Telegraph Co.

# "The Honour of Kings"

ALEXANDER GRAHAM BELL did not discover the telephone by haphazard. His invention was not an accident; it was a matter searched out. Before the first telephone was made, Professor Bell had formulated, in his mind's eye, the theory that electric currents, generated by a voice-vibrated armature in front of an electromagnet, could be made to produce electrical effects capable of transmitting speech. In the workshop of Mr. Charles Williams, Jr., 109 Court Street, Boston, on the second day of June, 1875, he confirmed his theory in the course of his classical experiments with tuned reeds, made preparatory to an experiment with multiple telegraph apparatus. When, on March 10, 1876, he said, "Mr. Watson, come here; I want you," and his words were transmitted over a short length of wire from his laboratory to his bedroom, in the boarding house at No. 5 Exeter Place, in Boston, and faithfully received, a new era in communication unfolded.

Research and development, in the system which bears his name, began with Bell. There is a passage in the Book of Proverbs which seems particularly applicable: "The honour of kings is to search out a matter." That is what Bell did; it is what his successors are still doing. His name heads the unbroken dynasty of scientists and engineers whose efforts, through half a century, have nurtured the telephone art from its simple beginnings to the complex organism which today makes neighbors of more than a hundred millions of Americans and, spanning the Atlantic, links the peoples of two continents in the bonds of speech.

When the telephone was born, there was available for use with it none of the thousands of parts now essential to a far-flung communication system. Knowledge, of course, existed of certain properties of the metals, such as copper, iron, nickel, platinum, lead, antimony and

many other elements and organic materials, which have subsequently been taught to play their roles in the vast modern telephone system; but until the matter of how to utilize them in the design and construction of such apparatus as cables, loading coils, repeaters and switchboards had been searched out, these substances were as far removed from practically useful telephonic apparatus as the words in the dictionary are remote from our classics of literature. The possibilities were latent; the human mind had not yet conceived them. And the touch of the artist was needed to search out the matter. There were three ways in which the telephonic art in all its various phases, might have been developed to meet operating needs. Each Associated Operating Company of the Bell System, acting by itself, through a large additional force of employees, and by retaining the services of physicists, chemists, mathematicians, metallurgists, designing engineers and other kinds of scientists and specialists, might have undertaken to develop its own methods, using its plant as an experimental laboratory (perhaps to the detriment of service to the telephone user) and to invent and design the new apparatus constantly required to meet the increasing and changing requirements of its business. Not only was new apparatus needed, but also the best methods for planning the growth of the plant, for installing it, for handling the traffic and for conducting every branch of the business had to be determined by trial and experiment, worked out, developed and made practically applicable. The art of telephony has always been continuously in a state of change and improvement. So rapid has been its growth and so radical its changes that the devices and methods of one period have been incapable of meeting the needs of the next period. If this plan (each company for itself) had been followed, much duplication of effort would have resulted and coordination of plant and practices between companies would have been difficult.

A second way would have been for each Associated Company to have done nothing to provide for its needs in respect of all these matters, hoping and trusting that there might always be someone, somewhere, who would be in a position to sell to it something that it could use in some way. Had this plan been followed, such improvements as came would have had to await the successful efforts of those outside the business of supplying telephone service and, consequently, less familiar with its demands and requirements than those more intimately connected with it.

The third way was for the Associated Operating Companies to employ a centralized organization, working all the time for all of them, to perform all of those things which could most effectively and efficiently be done for all, in common, by such a central institution.

The greatest credit is due to the founders of the Bell System for their vision in selecting the last of these three ways. The merit of their choice is evident when the efficiency of telephone service and the extent of its use by the public in the United States is contrasted with that in other parts of the world. From the beginning this plan has been a most important factor contributing to the expansion and improvement of the Bell System. A remarkable continuity has characterized its pursuit of the search for advancement by means of invention and experimentation, ever becoming better and better coordinated, as the years have passed, by the application of added experience in organization and administrative methods.

In this work the world's store of general scientific knowledge has always been utilized to the full, but the fact stands out that the fruits of pure research in the various sciences rarely, if ever, admit of direct application in telephony. Skillful development work frequently requiring years of patient effort by highly trained engineers and specialized technical experts is needed before some

general conception can be translated and crystallized into a definite, improved piece of apparatus, system or method capable of practical utilization in the working telephone system.

The enormous strides in all branches of the physical and other sciences that the first quarter of the present century has witnessed have had an important reaction on the methods of conducting development and research work in the Bell System. In the early years, there was, literally, no profession of electrical engineering. Such knowledge of electrical theory as existed at that time was so incomplete and elementary that much of the experimentation and design could proceed only by "cut and try" methods. For example, the production of an improved induction coil, in 1893, required a series of hundreds of experimental coils to be made, one after another, each differing slightly from the others and embodying the lessons learned from testing those which preceded it. Only in that way could such vital matters as the dimensions of the core and the best sizes of wire and numbers of turns for both primary and secondary windings be determined. At the present time, coil design has become much more nearly an exact science through the application of the greater knowledge that now exists of the physical laws of electromagnetic induction and of the values of the various electrical and magnetic constants which are involved.

New views as to the composition and structure of the atom and increasing knowledge of the behavior of electrons whose very existence was unsuspected comparatively few years ago, are placing new tools in the hands of the mathematical physicists of the Bell Telephone Laboratories and the Department of Development and Research of the American Company. To these modern scientific discoveries they, themselves, have made and are making important contributions for, in many instances, it is becoming necessary to advance the frontiers of pure

science and to solve baffling problems in fundamental research in order to lay the foundations for further advances in telephony. No one can say with assurance what some of these advances will be. We only know that, when realized, they will contribute to a better and broader telephone service.

F. L. RHODES.

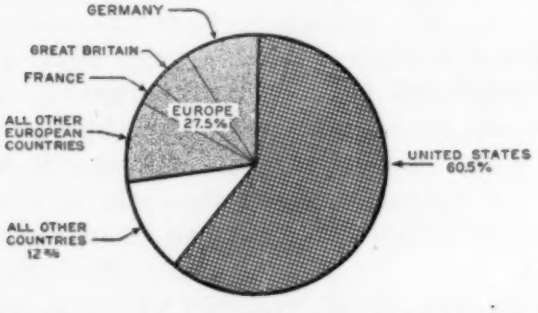
# World's Telephone Statistics
# January 1, 1927

THE survey of the telephone development of all countries in the world, which is made annually by the Chief Statistician's Division of the American Telephone and Telegraph Company, has recently been completed for January 1, 1927. According to this survey, there were on that date 29,378,430 telephones in use throughout the world, representing an increase during 1926 of 1,484,677 telephones, or 5.3%.

Of all telephones in the world, 17,746,168, or nearly 60.5%, were in the United States; and of these over 99% were either owned by, or connected to, the Bell System. Europe had 8,080,642 telephones, or 27.5% of the world's

DISTRIBUTION OF THE WORLD'S TELEPHONES

— January 1, 1927 —



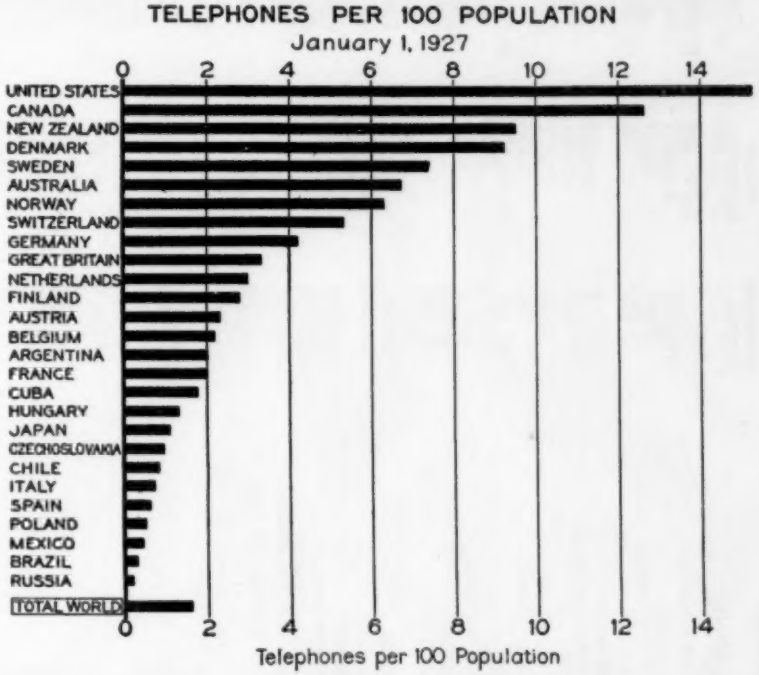

total, while the remaining 12%, or 3,551,620 telephones, were distributed among the countries of Asia, Africa, Oceania, South America and North America outside of the United States.

In the course of this survey authoritative statistics were obtained from the telephone systems of all countries either through official reports or through special correspondence, such correspondence being conducted with some 500 telephone officials throughout the world. As in former years, these statistics have been printed in

pamphlet form, and the accompanying tables and charts have been reproduced from this pamphlet. The data are self-explanatory and require little comment.

### Comparative Telephone Development of Countries

The table on "Telephone Development of the World, By Countries" shows that, on January 1, 1927, the United States had 15.3 telephones in service for each 100 inhabitants, leading all other countries in the number of telephones in proportion to population. Canada ranked next to the United States in this respect, having 12.6 telephones per 100 population. New Zealand, with 9.5 telephones per 100 inhabitants, was in third place,




closely followed by Denmark with 9.2. Sweden, with 7.4 telephones per 100 population, ranked fifth, followed by Australia with 6.7, Hawaii with 6.5, and Norway with

## TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES
### January 1, 1927

| | Number of Telephones | | | Per Cent of Total World | Telephones per 100 Population | Increase in Number of Telephones During 1926 |
|---|---|---|---|---|---|---|
| | Government Systems | Private Companies | Tota | | | |
| NORTH AMERICA: | | | | | | |
| United States | ..... | 17,746,168 | 17,746,168 | 60.40% | 15.3 | 810,250 |
| Canada | 216,438 | 984,650 | 1,201,088 | 4.09% | 12.6 | 58,212 |
| Central America | 8,263 | 12,020 | 20,283 | .07% | 0.3 | 269 |
| Mexico | 1,427 | 56,136 | 57,563 | .20% | 0.4 | 3,098 |
| West Indies: | | | | | | |
| Cuba | 530 | 64,686 | 65,216 | .22% | 1.8 | 3,102 |
| Porto Rico | 841 | 12,533 | 13,374 | .05% | 0.9 | 614 |
| Other W. I. Places* | 7,588 | 10,572 | 18,160 | .06% | 0.3 | 285 |
| Other No. Am. Places* | 100 | 8,405 | 8,505 | .03% | 2.4 | 484 |
| Total | 235,187 | 18,895,170 | 19,130,357 | 65.12% | 12.0 | 876,314 |
| EUROPE: | | | | | | |
| Austria | 158,429 | ..... | 158,429 | .54% | 2.3 | 5,386 |
| Belgium | 176,572 | ..... | 176,572 | .60% | 2.2 | 17,500 |
| Bulgaria | 10,010 | ..... | 10,010 | .03% | 0.2 | 1,010 |
| Czechoslovakia | 128,956 | ..... | 128,956 | .44% | 0.9 | 8,408 |
| Denmark | 13,253§ | 307,856 | 321,109 | 1.09% | 9.2 | 4,712 |
| Finland | ..... | 98,556 | 98,556 | .33% | 2.8 | 13,556 |
| France | 818,971 | ..... | 818,971 | 2.79% | 2.0 | 81,773 |
| Germany | 2,688,495 | ..... | 2,688,495 | 9.15% | 4.2 | 100,479 |
| Great Britain and No. Ireland | 1,511,585 | ..... | 1,511,585 | 5.14% | 3.3 | 120,429 |
| Greece | 6,328 | ..... | 6,328 | .02% | 0.1 | 828 |
| Hungary | 114,660 | ..... | 114,660 | .39% | 1.4 | 9,000* |
| Irish Free State (March 31, 1927) | 23,830 | ..... | 23,830 | .08% | 0.8 | 1,977 |
| Italy (June 30, 1927) | ..... | 272,433 | 272,433 | .93% | 0.7 | 23,256 |
| Jugo-Slavia | 28,378 | ..... | 28,378 | .10% | 0.2 | —1,564 |
| Latvia (March 31, 1927) | 24,192 | ..... | 24,192 | .08% | 1.2 | 5,349 |
| Netherlands | 225,348 | ..... | 225,348 | .77% | 3.0 | 11,307 |
| Norway | 101,567‡ | 73,933 | 175,500 | .60% | 6.3 | 1,748 |
| Poland | 74,153 | 57,798 | 131,951 | .45% | 0.5 | 11,721 |
| Portugal | 3,000* | 19,450 | 22,450 | .08% | 0.4 | 1,594 |
| Roumania | 53,274 | ..... | 53,274 | .18% | 0.3 | 6,000* |
| Russia† | 225,409 | ..... | 225,409 | .77% | 0.2 | 32,627 |
| Spain | ..... | 131,519 | 131,519 | .45% | 0.6 | 9,437 |
| Sweden | 448,832 | 1,814 | 450,646 | 1.53% | 7.4 | 16,052 |
| Switzerland | 210,486 | ..... | 210,486 | .72% | 5.3 | 10,275 |
| Other Places in Europe* | 53,709 | 17,846 | 71,555 | .24% | 1.0 | 2,765 |
| Total | 7,099,437 | 981,205 | 8,080,642 | 27.50% | 1.6 | 495,625 |

| | | | | | | |
|---|---|---|---|---|---|---|
| SOUTH AMERICA: | | | | | | |
| Argentina | ..... | 204,463 | 204,463 | .70% | 2.0 | 15,427 |
| Bolivia* | ..... | 1,824 | 1,824 | .01% | 0.1 | ..... |
| Brazil | 632 | 104,577 | 105,209 | .35% | 0.3 | 1,593 |
| Chile | ..... | 36,860 | 36,860 | .13% | 0.8 | 1,696 |
| Colombia | 50 | 18,825 | 18,875 | .06% | 0.2 | 483 |
| Ecuador* | 1,691 | 2,827 | 4,518 | .02% | 0.2 | ..... |
| Paraguay | 183 | 230 | 413 | .001% | 0.03 | —48 |
| Peru | ..... | 13,229 | 13,229 | .05% | 0.2 | 2,229 |
| Uruguay | ..... | 26,915 | 26,915 | .09% | 1.6 | 864 |
| Venezuela | 612 | 12,120 | 12,732 | .04% | 0.4 | 677 |
| Other Places | 2,708 | ..... | 2,708 | .01% | 0.6 | 66 |
| Total | 5,876 | 421,870 | 427,746 | 1.46% | 0.5 | 22,987 |
| ASIA: | | | | | | |
| British India (March 31, 1927) | 16,140 | 29,758 | 45,898 | .15% | 0.01 | 2,659 |
| China* | 85,644 | 39,677 | 125,321 | .43% | 0.03 | 7,547 |
| Japan (March 31, 1927) | 648,091 | ..... | 648,091 | 2.21% | 1.1 | 11,355 |
| Other Places in Asia* | 90,946 | 18,275 | 109,221 | .37% | 0.1 | 384 |
| Total | 840,821 | 87,710 | 928,531 | 3.16% | 0.1 | 21,945 |
| AFRICA: | | | | | | |
| Egypt | 37,705 | ..... | 37,705 | .13% | 0.2 | 1,961 |
| Union of South Africa§ | 88,680 | ..... | 88,680 | .30% | 1.2 | 7,991 |
| Other Places in Africa* | 59,065 | 1,096 | 60,161 | .20% | 0.1 | 6,146 |
| Total | 185,450 | 1,096 | 186,546 | .63% | 0.1 | 16,098 |
| OCEANIA: | | | | | | |
| Australia (June 30, 1926) | 403,616 | ..... | 403,616 | 1.37% | 6.7 | 40,667 |
| Dutch East Indies | 39,355 | 3,544 | 42,899 | .15% | 0.1 | 1,936 |
| Hawaii | ..... | 19,648 | 19,648 | .07% | 6.5 | 844 |
| New Zealand (March 31, 1927) | 137,307 | ..... | 137,307 | .47% | 9.5 | 7,121 |
| Philippine Islands | 4,731 | 13,083 | 17,814 | .06% | 0.1 | 848 |
| Other Places in Oceania* | 2,774 | 550 | 3,324 | .01% | 0.2 | 292 |
| Total | 587,783 | 36,825 | 624,608 | 2.13% | 0.8 | 51,708 |
| TOTAL WORLD | 8,954,554 | 20,423,876 | 29,378,430 | 100.00% | 1.6 | 1,484,677 |

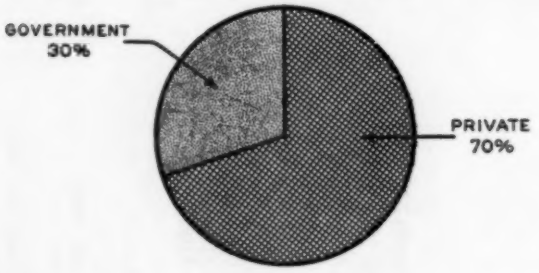
* Partly estimated.
§ March 31, 1927.
‡ June 30, 1926.
† Including Siberia and Associated Republics.

6.3. No other country or colonial possession had as many as 6 telephones per 100 inhabitants.

All telephones in the United States, as well as the great majority of the telephones in Canada, are operated by private companies. Largely as a result of the high development of telephone service which these companies have fostered, the table shows that 70% of the world's telephones are operated under the auspices of private enterprise.

Germany had more telephones (2,688,495) than any country of the world except the United States, but only 4.2 instruments per 100 population. Moreover, the increase in telephones in Germany during 1926 was only 100,479, a distinctly moderate gain which probably reflected unsettled economic conditions in that country. In Great Britain, 120,429 telephones were added during 1926, a numerical gain greater than that in Germany; but on January 1, 1927, there were still only 3.3 instruments per each 100 inhabitants of the United Kingdom. The telephone system of France also showed a relatively substantial increase of 81,773 telephones in 1926; however, the total number of telephones in France

OWNERSHIP OF THE WORLD'S TELEPHONES
January 1, 1927




was equivalent to but 2.0 instruments per 100 inhabitants, a development which is less than one-seventh of that of the United States. In Italy and Spain, where the Government telephone systems have recently been turned

## TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES
### January 1, 1927

| Country | Service Operated by (See Note) | Number of Telephones | | Telephones per 100 Population | |
|---|---|---|---|---|---|
| | | In Communities of 50,000 Population and Over | In Communities of less than 50,000 Population | In Communities of 50,000 Population and Over | In Communities of less than 50,000 Population |
| Austria (January 1, 1926) | G. | 112,664 | 40,379 | 5.0 | 0.9 |
| Belgium | G. | 130,742 | 45,830 | 4.1 | 1.0 |
| Canada | P. G. | 565,496 | 635,592 | 21.6 | 9.2 |
| Czechoslovakia | G. | 52,966 | 75,990 | 3.9 | 0.6 |
| Denmark | P. G. | 140,525 | 180,584 | 15.7 | 7.0 |
| France | G. | 476,000 | 342,971 | 5.5 | 1.1 |
| Germany | G. | 1,640,863 | 1,047,632 | 8.0 | 2.4 |
| Great Britain and No. Ireland* | G. | 1,110,742 | 432,049 | 4.7 | 1.8 |
| Japan (March 31, 1927) | G. | 426,679 | 221,412 | 3.6 | 0.5 |
| Netherlands | G. | 145,685 | 79,663 | 5.5 | 1.6 |
| New Zealand (March 31, 1927) | G. | 49,634 | 87,673 | 9.3 | 9.6 |
| Norway | P. G. | 57,396 | 118,104 | 14.2 | 5.0 |
| Poland | P. G. | 70,344 | 61,607 | 2.3 | 0.2 |
| Sweden | G. | 169,229 | 281,417 | 19.9† | 5.4 |
| Switzerland | G. | 88,239 | 122,247 | 11.4 | 3.8 |
| United States | P. | 9,306,289 | 8,439,879 | 20.6 | 11.9 |

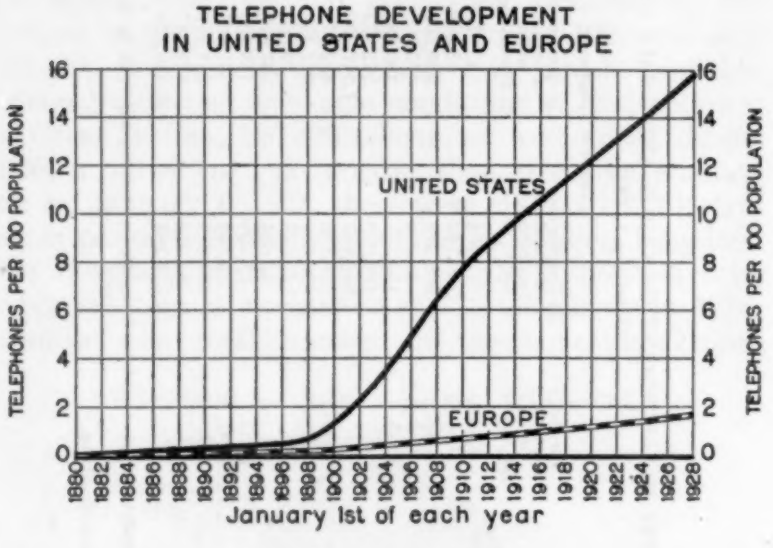
Note: P. indicates telephone service operated by private companies, G. by the Government, and P. G. by both private companies and the Government.

* March 31, 1927.

† The majority of this development is due to Stockholm.

over to private companies which are reconstructing them along modern lines, substantial progress may be expected in the future. The number of telephones in the United States increased during 1926 by 810,250, a gain in one year almost equal to the total number of instruments in the whole of France.

The best developed country in South America, from a telephone standpoint, was Argentina, with 2.0 telephones per 100 population, a density exceeding that of some European countries. In Asia the leading country tele-

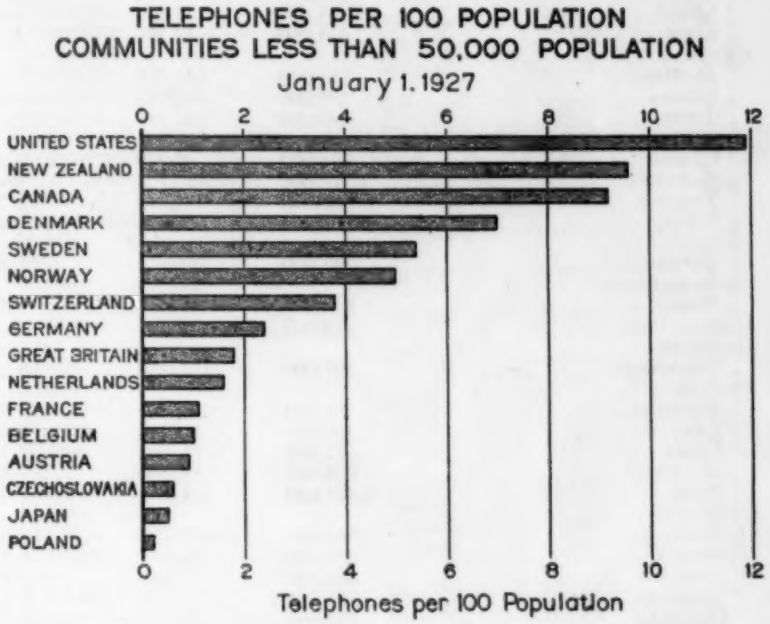



phonically is Japan, which had 1.1 instruments per 100 population, a development which was slightly exceeded by the foremost country of Africa—the Union of South Africa—which had 1.2 telephones per 100 population.

### Telephones in Large and Small Communities

The table on "Telephone Development of Large and Small Communities" is of interest as indicating the comparative extent to which the smaller communities have been provided with telephone facilities in various im-

portant countries. In the United States the expansion of telephone service has been vigorously pushed in the towns and rural districts as well as in the large cities, with the result that on January 1, 1927, communities of less than 50,000 population had 11.9 telephones per 100 inhabitants,—a degree of development which is greater




than the total telephone density of any country except Canada. New Zealand, a country of few cities, ranks next to the United States in respect of telephone facilities in the smaller communities, with Canada a close third. Denmark, Sweden, and Norway—the Scandinavian countries—follow with 7.0, 5.4 and 5.0 telephones per 100 population, respectively. The virtual absence of rural telephone service in the other countries is reflected by the fact that all communities of less than 50,000 population had, in Germany, only 2.4 instruments for each 100 inhabitants, in Great Britain only 1.8, and in France only 1.1.

## TELEPHONE DEVELOPMENT OF LARGE CITIES

**January 1, 1927**

| Country and City (or Exchange Area) | Estimated Population (City or Exchange Area) | Number of Telephones | Telephones per 100 Population |
|---|---|---|---|
| ARGENTINA: | | | |
| Buenos Aires | 2,000,000 | 112,137 | 5.6 |
| AUSTRALIA: | | | |
| Adelaide | 317,000 | 27,385 | 8.6 |
| Brisbane | 274,000 | 20,122 | 7.3 |
| Melbourne | 944,000 | 80,301 | 8.8 |
| Sydney | 1,071,000 | 94,812 | 8.9 |
| AUSTRIA: (January 1, 1926) | | | |
| Gratz | 157,000 | 7,146 | 4.6 |
| Vienna | 1,919,000 | 98,226 | 5.1 |
| BELGIUM: | | | |
| Antwerp | 499,000 | 25,738 | 5.2 |
| Brussels | 903,000 | 61,267 | 6.8 |
| Charleroi | 186,000 | 5,174 | 2.8 |
| Ghent | 268,000 | 7,379 | 2.8 |
| Liege | 411,000 | 12,187 | 3.0 |
| CANADA: | | | |
| Montreal | 848,000 | 150,681 | 17.8 |
| Ottawa | 176,000 | 34,949 | 19.9 |
| Toronto | 640,000 | 163,744 | 25.6 |
| CHINA:* | | | |
| Canton | 934,000 | 2,900 | 0.3 |
| Shanghai | 1,575,000 | 25,731 | 1.6 |
| Tientsin | 838,000 | 8,810 | 1.1 |
| Peking | 1,350,000 | 42,000 | 3.1 |
| CUBA: | | | |
| Havana | 581,000 | 45,043 | 7.8 |
| CZECHOSLOVAKIA: | | | |
| Prague | 711,000 | 30,345 | 4.3 |
| DANZIG, FREE CITY OF | 376,000 | 17,010 | 4.5 |
| DENMARK: | | | |
| Copenhagen | 767,000 | 124,021 | 16.2 |
| FRANCE: | | | |
| Bordeaux | 256,000 | 12,700 | 5.0 |
| Lille | 202,000 | 11,388 | 5.6 |
| Lyons | 571,000 | 21,266 | 3.7 |
| Marseilles | 652,000 | 19,859 | 3.0 |
| Paris | 2,871,000 | 284,261 | 9.9 |
| GERMANY: | | | |
| Berlin | 4,064,000 | 428,949 | 10.6 |
| Bremen | 298,000 | 28,279 | 9.5 |
| Breslau | 563,000 | 37,903 | 6.7 |
| Chemnitz | 335,000 | 23,813 | 7.1 |
| Cologne | 707,000 | 58,837 | 8.3 |
| Dresden | 625,000 | 52,737 | 8.4 |
| Düsseldorf | 437,000 | 38,272 | 8.8 |
| Essen | 476,000 | 24,751 | 5.2 |
| Frankfort-on-Main | 473,000 | 51,859 | 11.0 |
| Hamburg-Altona | 1,278,000 | 143,755 | 11.2 |
| Hanover | 427,000 | 31,698 | 7.4 |
| Leipzig | 686,000 | 59,155 | 8.6 |
| Magdeburg | 297,000 | 19,136 | 6.4 |
| Munich | 700,000 | 63,798 | 9.1 |
| Nuremburg | 471,000 | 31,668 | 6.7 |
| Stuttgart | 345,000 | 36,331 | 10.5 |
| GREAT BRITAIN AND NO. IRELAND: (March 31, 1927) | | | |
| Belfast | 419,000 | 12,944 | 3.1 |
| Birmingham | 1,080,000 | 40,537 | 3.7 |
| Blackburn | 128,000 | 3,831 | 3.0 |
| Bolton | 180,000 | 4,994 | 2.8 |
| Bradford | 317,000 | 15,793 | 5.0 |
| Bristol | 394,000 | 14,731 | 3.7 |
| Edinburgh | 424,000 | 22,623 | 5.3 |
| Glasgow | 1,130,000 | 48,178 | 4.3 |
| Hull | 344,000 | 15,190 | 4.4 |
| Leeds | 487,000 | 17,872 | 3.7 |
| Liverpool | 1,126,000 | 49,061 | 4.4 |
| London | 7,480,000 | 532,066 | 7.1 |
| Manchester | 1,066,000 | 52,424 | 4.9 |
| Newcastle | 463,000 | 16,733 | 3.6 |
| Nottingham | 296,000 | 12,643 | 4.3 |
| Plymouth | 212,000 | 5,150 | 2.4 |
| Sheffield | 496,000 | 15,740 | 3.2 |

*Partly estimated.

## TELEPHONE DEVELOPMENT OF LARGE CITIES—(Concluded)

**January 1, 1927**

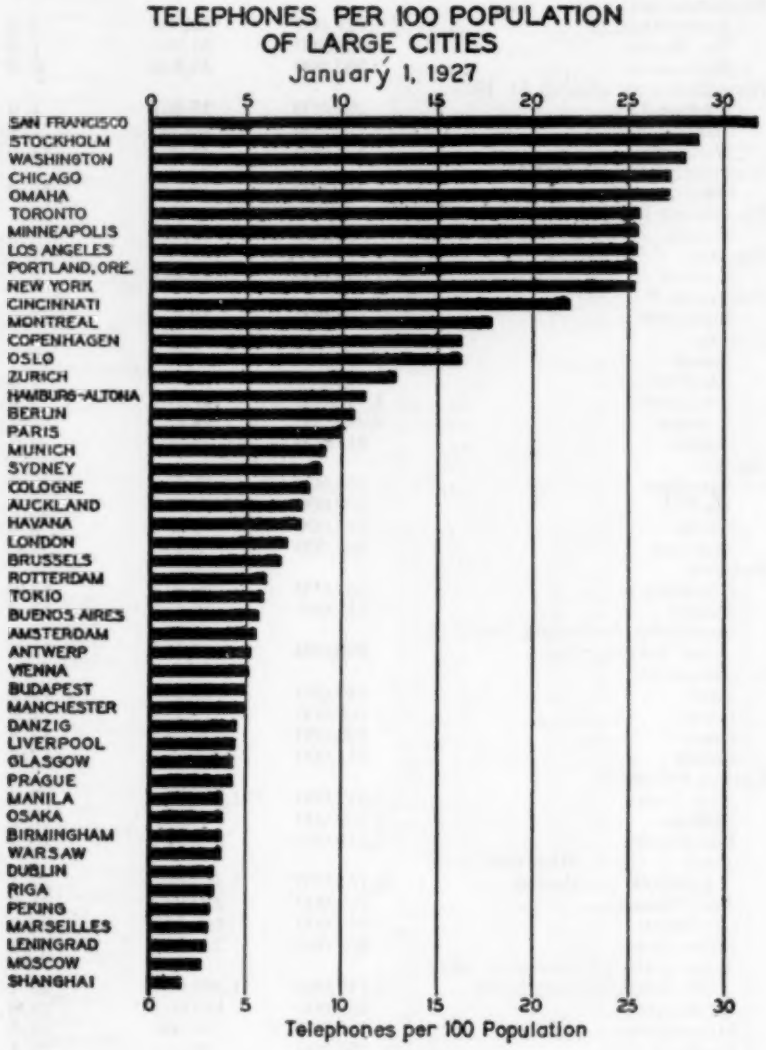
| Country and City (or Exchange Area) | Estimated Population (City or Exchange Area) | Number of Telephones | Telephones per 100 Population |
|---|---|---|---|
| HUNGARY: | | | |
| Budapest | 985,000 | 49,120 | 5.0 |
| Szegedin | 126,000 | 2,359 | 1.9 |
| IRISH FREE STATE: (March 31, 1927) | | | |
| Dublin | 410,000 | 13,325 | 3.3 |
| JAPAN: (March 31, 1927) | | | |
| Kobe | 659,000 | 25,036 | 3.8 |
| Kyoto | 717,000 | 29,107 | 4.1 |
| Nagoya | 835,000 | 24,980 | 3.0 |
| Osaka | 2,260,000 | 86,100 | 3.8 |
| Tokio | 2,143,000 | 125,649 | 5.9 |
| Yokohama | 529,000 | 12,696 | 2.4 |
| LATVIA: (March 31, 1927) | | | |
| Riga | 343,000 | 11,215 | 3.3 |
| NETHERLANDS: | | | |
| Amsterdam | 727,000 | 39,804 | 5.5 |
| The Hague | 409,000 | 31,036 | 7.6 |
| Rotterdam | 563,000 | 33,833 | 6.0 |
| NEW ZEALAND: (March 31, 1927) | | | |
| Auckland | 202,000 | 15,957 | 7.9 |
| Christchurch | 122,000 | 10,290 | 8.4 |
| Wellington | 127,000 | 15,997 | 12.6 |
| NORWAY: (June 30, 1926) | | | |
| Oslo | 252,000 | 40,872 | 16.2 |
| PHILIPPINE ISLANDS: | | | |
| Manila | 332,000 | 12,689 | 3.8 |
| POLAND: | | | |
| Warsaw | 1,029,000 | 38,487 | 3.7 |
| ROUMANIA:* | | | |
| Bucharest | 800,000 | 12,532 | 1.6 |
| RUSSIA: | | | |
| Kazan | 175,000 | 1,625 | 0.9 |
| Kharkov | 410,000 | 5,040 | 1.2 |
| Leningrad | 1,616,000 | 47,150 | 2.9 |
| Moscow | 2,019,000 | 54,936 | 2.7 |
| Odessa | 411,000 | 3,200 | 0.8 |
| SPAIN: | | | |
| Barcelona | 753,000 | 19,758 | 2.6 |
| Madrid | 800,000 | 19,432 | 2.4 |
| Seville | 214,000 | 1,861 | 0.9 |
| Valencia | 265,000 | 3,939 | 1.5 |
| SWEDEN: | | | |
| Göteborg | 231,000 | 29,913 | 13.0 |
| Malmö | 117,000 | 15,416 | 13.2 |
| Stockholm (excluding Bromma and Brännkyrka) | 389,000 | 111,487 | 28.7 |
| SWITZERLAND: | | | |
| Basel | 140,000 | 15,262 | 10.9 |
| Berne | 108,000 | 12,482 | 11.6 |
| Geneva | 126,000 | 16,084 | 12.8 |
| Zurich | 211,000 | 26,987 | 12.8 |
| UNITED STATES:** | | | |
| New York | 5,942,000 | 1,502,376 | 25.3 |
| Chicago | 3,120,000 | 848,017 | 27.2 |
| Los Angeles | 1,210,000 | 307,471 | 25.4 |
| Total of the 8 cities with over 1,000,000 population | 17,754,000 | 4,105,693 | 23.1 |
| San Francisco | 721,000 | 229,935 | 31.9 |
| Cincinnati | 664,000 | 145,707 | 21.9 |
| Milwaukee | 639,000 | 129,151 | 20.2 |
| Total of the 10 cities with 500,000–1,000,000 population | 6,717,000 | 1,286,054 | 19.1 |
| Washington | 496,000 | 139,032 | 28.0 |
| Minneapolis | 470,000 | 119,666 | 25.5 |
| Portland, Ore | 355,000 | 90,161 | 25.4 |
| Omaha | 230,000 | 62,169 | 27.1 |
| Total of the 30 cities with 200,000–500,000 population | 8,882,000 | 1,797,362 | 20.2 |
| Total of the 48 cities with over 200,000 population | 33,353,000 | 7,189,109 | 21.6 |

* Partly estimated.

** There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups and the development of certain representative cities within each of such groups.

## Telephones in Large Cities

The relative size of the telephone systems of the largest cities throughout the world is shown in the table on "Telephone Development of Large Cities." Among the cities listed in this table the highest development is found in San Francisco, which had 31.9 telephones per 100 popu-



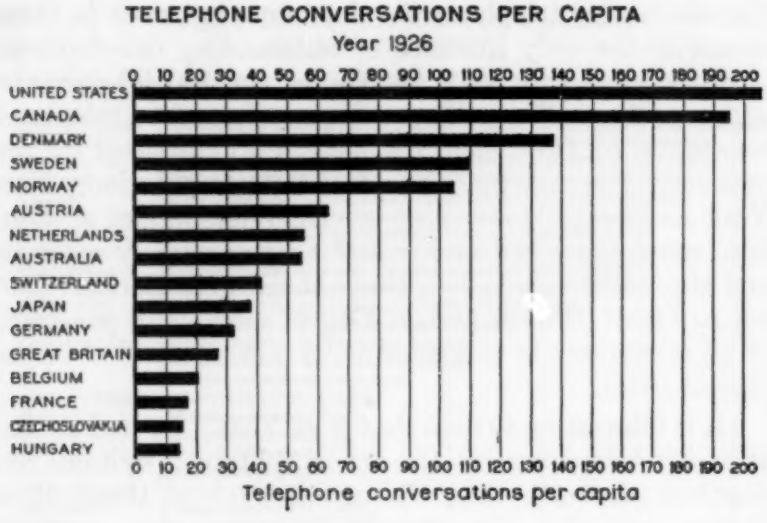
lation on January 1, 1927. In general, American cities have been provided with from 20 to 30 instruments for each 100 inhabitants, whereas foreign cities having more than 10 telephones per 100 inhabitants are exceptions rather than the rule; in Great Britain, for example, most cities have less than 5 telephones per 100. The Scandinavian countries rank next to the United States and Canada in city telephone development; but even in these countries the only instance of outstanding development is Stockholm, with 28.7 telephones per 100 inhabitants, where an aggressive private company furnished telephone service up to 1918 when its plant was purchased by the national Government. In relation to population, New York had nearly four times as many telephones as London, more than two and a half times as many as Paris and almost two and a half times as many as Berlin. And yet in Great Britain and in France more than one-third of all telephones in the country were concentrated in the capital cities.

It is interesting to note that New York City had almost as many telephones as the whole of Great Britain and Northern Ireland, that Chicago had more than all of France, and that Los Angeles had nearly as many as Austria and Belgium combined. In fact, the eight cities in the United States with a population of one million or more had more than half as many telephones as the whole of Europe.

## Comparative Use of the Telephone

The chart entitled "Telephone Conversations Per Capita" indicates that there were 205 telephone conversations for each man, woman and child in the United States during 1926, and that this country led the world in the degree to which its people made use of telephone facilities. Canada came next with 195 telephone conversations per capita. Germany, which ranked second to the United States in total number of telephones, re-

ported only 32 telephone conversations per capita, or less than a third of the per capita use in each of the Scandinavian countries. Throughout Great Britain there were only 27 telephone calls per capita, which was less than Germany's usage but considerably more than the 17 calls per capita indicated for France.



# Abstracts of Recent Technical Papers from Bell System Sources

*Precision Tool Making for the Manufacture of Telephone Apparatus*,[1] by J. H. Kasley and F. P. Hutchison. There are probably few industries in which the refinements of the tool making art have been carried further than in the manufacture of telephone apparatus and equipment, especially when handled on a large production basis as by the Western Electric Company. The purpose of this article is to outline some of the refinements of the tool making art as practiced by this Company and to do this, illustrative material has been drawn from among the large number of punches and dies used for punch press methods of manufacture. The methods employed and precision necessary in building the tools discussed can be considered as representative of the high class of workmanship required throughout the Company's tool rooms.

*Frequency Relations in Electrical Communication*,[2] by R. V. L. Hartley. A quantitative measure of "information" is developed which is based on physical as contrasted with psychological considerations. How the rate of transmission of this information over a system is limited by the distortion resulting from storage of energy is discussed from the transient viewpoint. The relation between the transient and steady state viewpoints is reviewed. It is shown that when the storage of energy is used to restrict the steady state transmission to a limited range of frequencies the amount of information that can be transmitted is proportional to the product of the width of the frequency-range by the time it is available. Several illustrations of the application of this principle to practical systems are included. In the case of picture transmission and television the spacial variation of intensity is

[1] Bell System Technical Journal, July, 1928.

[2] Bell System Technical Journal, July, 1928; presented before International Congress of Telegraphy and Telephony, Como, Italy, Sept., 1927

analyzed by a steady state method analogous to that commonly used for variations with time.

*The Natural Period of Linear Conductors,*[3] by C. R. Englund. This paper describes the experimental determination of the frequency of free electrical oscillation of straight rods and circular loops. The results agree more closely with the formula of Abraham than with that of MacDonald. For three rods whose lengths were 300 cm., 150 cm. and 227.1 cm., the ratio of wave length at resonance to rod length had the values 2.11, 2.13 and 2.13, respectively. Measurements taken upon 250 cm. rods bent into circular arcs of different radii gave values of the ratio of resonant wave length to arc length which passed through a minimum value and were virtually independent of the radius of the arc over a wide range, deviating markedly only at the extreme values of minimum possible and infinite radius. The extreme measured range of the ratio was 2.05 to 2.16. The wave lengths were measured upon a pair of Lecher wires and a very satisfactory meter for the rapid comparison of waves of short length was found to be a quarter wave length Lecher frame. This frame showed a constant end correction so that $\lambda=4(d+3.1)$, d being the length of the parallel rods.

*The Measurement of Capacitance in Terms of Resistance and Frequency,*[4] by J. G. Ferguson and B. W. Bartlett. The adaptation of a bridge circuit due to M. Wien together with apparatus and procedure is described which permits measurement of capacitance in terms of resistance and frequency with an accuracy comparable to that of the primary standards. Among its advantages over the Maxwell method commonly employed are the use of a single frequency voltage and the fact that there is no general limitation placed on the type of condenser which may be measured or on the frequency at which the

[3] Bell System Technical Journal, July, 1928.
[4] Bell System Technical Journal, July, 1928.

measurement may be made. The method is also applicable to the determination of inductance since its unit, like that of capacitance, may be derived from the units of resistance and frequency.

*Carrier Systems on Long Distance Telephone Lines*,[5] by H. A. Affel and C. S. Demarest and C. W. Green. An A. I. E. E. paper in 1921 gave a very complete resumé of the activities of the Bell System at that time in the development of multiplex telephone and telegraph systems using carrier current methods. The authors in the present paper describe developments which have resulted in improvements in the carrier telephone art since that time. A new, so-called type "C" system is described in detail, together with suitable repeaters and pilot channel apparatus for insuring stability of operation; the line problems are considered and typical installations pictured. The growth of the application of carrier telephone systems and their increasingly important part in providing long distance telephone service on open-wire lines are shown.

*A Modification of the Rayleigh Disk Method for Measuring Sound Intensities*,[6] by L. J. Sivian. The usual procedure is to measure the deflexion of the disk under the influence of a steady sound-field. This paper outlines a procedure which has been found useful when the sound amplitude can be made a suitable function of time. The scheme depends on the fact that the torque which the sound wave exerts on the disk is a non-linear function of the sound amplitude, being proportional to the square of the air particle velocity. The amplitude of the sound-wave to be measured is modulated with a frequency equal to that of the free vibration of the suspended disk. The measurement requires reading the amplitude of oscillations corresponding to the modulating frequency, rather

[5] Bell System Technical Journal, July, 1928.

[6] The London, Edinburgh, and Dublin Philosophical Magazine, and Journal of Science, Vol. 5, No. 29, March, 1928. pp. 615–620.

than a steady deflexion of the disk. The disturbances caused by spurious air currents are largely reduced. In addition, in many practical cases at least, there is a gain in absolute sensitivity. Both theory and experimental verification are given.

*Reflection of Electrons by a Crystal of Nickel*,[7] by C. J. Davisson and L. H. Germer. This is a report of some preliminary results obtained in a new series of experiments in which a beam of electrons exhibits the properties of a beam of waves. In previous experiments (Phys. Rev. 30, 705, 1927) a beam of electrons was directed at normal incidence against a face of a nickel crystal, and observations were made upon the diffraction beams which issued from the incidence side of the crystal at various critical speeds of bombardment. It was anticipated that if the angle of incidence were made other than zero a beam of electrons would be found issuing from the crystal at a series of critical speeds in the direction of regular reflection, and that the series of critical speeds would change with the incidence angle. This regularly and selectively reflected electron beam which is the analogue of the Bragg X-ray reflection beam has been found, and measurements have been made upon it. In the X-ray phenomenon the wave-length of the reflected beam at maximum intensity is related through a simple formula to the angle of incidence and a dimension of the reflecting crystal. This formula (Bragg's formula) does not obtain in the case of electron reflection because of the refraction of the electrons by the crystal. The departures from the Bragg relation are used to calculate indices of refraction of nickel for electrons of various speeds or wave lengths.

*Introduction to Mathematics of Statistics* [8] (282 pp.), by R. W. Burgess. This book discusses the best elementary methods of statistical analysis from the standpoint of a

[7] Proceedings of the National Academy of Sciences, April 15, 1928, Vol. 14, No. 4, pp. 317–322.

[8] Houghton-Mifflin Company.

beginner who has had one year of college mathematics, or some practical statistical experience and the ordinarly high school mathematics. "Statistical Analysis" is regarded in this book as the logical process by which large masses of quantitative facts may be classified, summarized, analyzed, and compared so as to yield reliable conclusions.

The topics treated include classification, formation of statistical series, use of ratios and percentages in statistical analysis, meaning and graphic discussion of frequency distributions, averages, index numbers, measures of dispersion, trend lines, analysis of seasonal variation, two, three, and four variable correlation, and the elements of sampling and probability. Emphasis is placed on the type of statistical problems most common in the social sciences, in which the data are subject to a higher degree of variability than in the usual problems in physics or astronomy which require the use of the theory of least squares or the Gaussian "curve of error".

*The Use of a Moving Beam of Light to Scan a Scene for Television,*[9] by F. Gray. The paper is a discussion of a method of scanning employed in a television system. A three dimensional subject is scanned directly by a moving beam of light to produce a picture current in photoelectric cells. This method permits the use of a very intense transient illumination and more than one large aperture photoelectric cell to collect reflected light. These two factors give a highly efficient optical system for producing a picture current at a transmitting station. The image seen at a distant station is the same as if light came out of the photoelectric cells to illuminate the subject and a small aperture lens formed an image of the subject for transmission. The television system transmits only the spacial variations of brightness and not the absolute brightness of the view, consequently, an additional steady illumination of a subject does not affect the reproduced image.

[9] Journal of the Optical Society of America, Vol. 16, pp. 177–190, March, 1928

*Maintaining High Standards in Products,*[10] by E. D. Hall. This article presents briefly but clearly the essential features of a method of keeping before the management an accurate picture of the relative quality of manufactured products. Defects are grouped into four classes and given demerit grades that represent the seriousness of the fault. Defects found each month are added, reduced to an average value, and plotted on charts which as a reference base use the average quality of the preceding five years. A method of computing averages for an entire line of products is also given.

*Probability and Its Engineering Uses* [11] (470 pp.), by Thornton C. Fry. This book on the theory of probability is written from the standpoint of the engineer. Its earlier chapters deal with the fundamental mathematical concepts that underlie the theory, and its later chapters develop these concepts in the directions of their application of traffic and trunking problems, curve fitting, and atomic physics.

Among the subjects which receive especial emphasis are: the logical standing of attempts to determine the probability of an event by trial; the physical significance of the fundamental distribution laws, such as the Normal, the Binomial and the Poisson Law; Pearson's criterion for "goodness of fit"; and trunking problems.

*Differential Intensity Sensitivity of the Ear for Pure Tones,*[12] by R. R. Riesz. The ratio of the minimum perceptible increment in sound intensity to the total intensity, $\Delta E/E$, which is called the differential sensitivity of the ear, was measured as a function of frequency and intensity. Measurements were made over practically the entire range of frequencies and intensities for which the ear is capable of sensation. The method used was that of beating tones, this method giving the simplest

[10] Manufacturing Industries, Vol. 16, No. 1, pp. 17–19, May, 1928.
[11] D. Van Nostrand Company, March, 1928.
[12] The Physical Review, May, 1928, Vol. 31, No. 5, pp. 867–875.

transition from one intensity to another. The source of sound was a special moving coil telephone receiver having very little distortion, actuated by alternating currents from vacuum tube oscillators. Observations were made on twelve men. Average curves show that at any frequency, $\Delta E/E$ is practically constant for intensities greater than $10^6$ times the threshold intensity; near the auditory threshold $\Delta E/E$ increases. Therefore Weber's law, $\Delta E/E$ = a constant for a given frequency, holds above this intensity, the value of the ratio line between 0.05 and 0.15 depending on the frequency. As a function of frequency $\Delta E/E$ is a minimum at about 2500 c.p.s., the minimum being more sharply defined at low sound intensities than it is at high. This frequency corresponds to the region of greatest absolute sensitivity of the ear. Analytical expression are given (Eqs. (2), (3), (4) and (5) ) which represent $\Delta E/E$, within the error of observation, as a function of frequency and intensity. Using these equations it is calculated that at about 1300 c.p.s. the ear can distinguish 370 separate tones between the threshold of audition and the threshold of feeling.

*Use of the Noble Metals for Electrical Contacts,*[13] by E. F. Kingsbury. The paper describes the results of an investigation of the behavior of gold, silver and the platinum metals as electrical contacts in communication circuits. Platinum has heretofore been considered the standard although some alloys of the platinum metals have been used in especially severe conditions. The economic situation has, however, encouraged the use of cheaper substitutes. Heretofore, accurate knowledge has not been available concerning the intrinsic merit of other materials. This problem is complicated by the various forms of discharges and mechanical conditions encountered in practice. The resistance, erosion, and transfer of contacts are discussed for a variety of materials under various circuit conditions and in different atmospheres.

[13] Technical Publication No. 95, A. I. M. M. E., March, 1928.

*Economic Aspects of Engineering Applications of Statistical Methods*,[14] by W. A. Shewhart. This note calls attention to possible applications of modern mathematical statistical theory, to research, design, production, inspection, supply, and other engineering problems. Attention is given to certain general types of problems in the solution of which statistical applications have been made, and to the nature of the possible economies effected thereby. It is reasonable to believe that very definite economic advantages can be obtained in any large industry through such applications.

*Evaluating Quality in Heat Treated High Speed Steel by Means of the Milling Cutter*,[15] by J. B. Mudge and F. E. Cooney. A test of heat treated high speed steel in the form of milling cutters, the variables having been reduced to a minimum, and the dulling point of the cutting edges of the tools determined by a recording wattmeter connected in the circuit of the motor of the milling machine. A "deadline" test resulted instead of the usual "breakdown" test.

It was found that:

Cutters of the same steel hardened by the same method check within limits that are sufficiently close for test purposes.

No cast cutter has been found to give results comparable to standard high speed steel refined by suitable working. Cutters hardened by patented or salt bath processes have not given results comparable to standard high speed steel hardened by the open fire method.

*A Bridge Method for the Measurement of Inter-Electrode Admittance in Vacuum Tubes*,[16] by E. T. Hoch. A description is given of the Colpitts-Campbell bridge as applied specifically to the measurement of direct admittances in vacuum tubes. Data are given on several tubes.

[14] Journal of the Franklin Institute, Vol. 205, March, 1928, pp. 395–405.

[15] Transactions of the American Society for Steel Treating, February, 1928, Vol. 13, No. 2, pp. 221–239.

[16] Proceedings of the I. R. E., April, 1928, Vol. 16, No. 4, pp. 487–493.

*On Electrical Fields near Metallic Surfaces,*[17] by Jospeh A. Becker and Donald W. Mueller. When an electron escapes from a metallic surface it passes through fields which tend to pull it back. Properly directed applied fields partially neutralize the surface fields and hence reduce the work the electron has to do against these fields. That is why $i$, the thermionic current, increases steadily with $F_a$, the applied field. Quantitatively $d(\log_{10} i)/dF_a = (11600/2.3\ T)\ Xs$, where $T$ is the temperature of the surface and $s$ is the distance from the surface at which the surface field $F$ is equal to $F_a$. Hence the slope of an experimental log $i$ vs. $F_a$ curve at any $F_a$ yields the value of $s$ corresponding to $Fs$. For clean or atomically homogeneous surfaces experiment shows that the only force opposing the escaping electron is due to its image field; for composite surfaces other fields, which are ascribed to the adsorbed ions, are superposed on the image field. For 70 per cent. thoriated tungsten this "adsorption field" is very large close to the surface and in a direction to help electrons escape; it decreases rapidly in strength as $s$ increases until it is zero at about 15 atom diameters; here it reverses its direction and then increases in strength till it attains a maximum value of 8000 volts/cm at 75 atom diameters; beyond this distance it decreases steadily. The intense field close to the surface accounts for the decreased work function while the reverse field farther out accounts for the poor saturation at ordinary applied potentials.

The photo-electric long wave-length limit should be shifted toward the red by applied fields. This shift should be particularly noticeable for composite surfaces.

*Direct Determination of Rubber in Soft Vulcanized Rubber,*[18] by A. R. Kemp, W. S. Bishop, and T. J. Lackner. A modification of the Wijs method is shown

[17] Physical Review, Vol. 31, No. 3, March, 1928, pp. 431–440.

[18] Industrial and Engineering Chemistry, Vol. 20, No. 4, April, 1928, pp. 427-429.

to be suitable for determining the rubber content of vulcanized rubber.

A procedure for the direct determination of sulphur combined with rubber is outlined.

The effect of compounding ingredients is shown.

Results of analyses of four reclaimed rubbers by the proposed and difference methods are given for comparison.

*Effect of Grounding on Telephone Interference,*[19] by J. J. Pilliod. This paper presented before the Pittsburgh Section of the Association of Iron and Steel Electrical Engineers in February, 1928, is a rather complete although non-mathematical presentation of the inductive effects of power lines on nearby communication circuits. The production of noise on the latter circuits and the production of voltages sufficiently high to be prejudicial to the operators and users of these circuits are separately discussed. Comparisons are drawn between the inductive action of grounded and ungrounded power lines. Although free from mathematics, the paper gives a very good outline of the interference problem and points out the many opportunities presented for cooperative effort both in connection with original design and with reduction of interference on existing lines.

*Distortion Correction in Electrical Circuits with Constant Resistance Recurrent Networks,*[20] by Otto J. Zobel. Constant resistance recurrent networks, that is networks whose iterative impedances are a pure constant resistance at all frequencies, form here the basis of a method of distortion correction which is applicable to any electrical circuit. The paper takes up first the general problem of distortion correction, then this method of correction and its application in the following Parts and supplementary Appendices.

Part 1. Ideal Circuit Characteristics. Both ideal steady-state attenuation and phase characteristics are

[19] Iron and Steel Engineer, Vol. V, pages 147–155, April, 1928.

[20] Bell System Technical Journal, July, 1928.

formulated and then verified as being necessary and sufficient for the preservation of signal-shape under transient conditions.

Part 2. Constant Resistance Recurrent Networks. These networks are of three general types and are made possible by the introduction of inverse networks of constant impedance product. Their propagation characteristics are considered in some detail and various methods of design are indicated.

Part 3. Arbitrary Impedance Recurrent Networks. These networks are a generalization of those in Part 2.

Part 4. Applications. The large variety of uses to which these networks may be put is illustrated by specific designs made for complementary distortion correcting networks, for a submarine cable circuit, a loaded-cable program transmission circuit, and an open-wire television circuit. In addition, networks are given for the equalization of variable attenuation in carrier telephone circuits, for phase correction in the transatlantic telephone system and for the simulation of a smooth line.

Appendix I. Discussion of Linear Phase Intercept.

Appendix II. Linear Transducer Theorems.

These theorems are proved which relate to the variation with frequency over the entire frequency range of the propagation constants and iterative impedances of certain passive linear transducers.

Appendix III. Propagation Constant and Iterative Impedance Formulae for General Ladder, Lattice and Bridged-T Types. This includes an improved formula for $\cosh^{-1}(x+iy)$.

Appendix IV. Propagation Characteristics and Formulae for Various Lattice Type Networks. These results can be applied quite readily to many problems arising in the design of distortion correcting networks.

*Photomicrography and Its Application to Mechanical Engineering*,[21] by Francis F. Lucas. This paper was pre-

[21] Mechanical Engineering, Vol. 50, No. 3, pp. 205–212, March, 1928.

sented at the annual meeting of the American Society of Mechanical Engineers during the week of December 5, 1927. It discusses the difference between magnification and resolution and stresses the difficulties in obtaining clear-cut photomicrographs at high magnifications. Until comparatively recently 1500 diameters was thought to be the limit.

The ultra-violet microscope should, theoretically give about double the resolution of one using visual light because of the shorter wave length, but until recently this has not been the case. The paper explains a mechanical focusing method used in Bell Telephone Laboratories by which a series of photographs are taken with a change in focus of one-sixteenth micron between successive exposures. A typical set of four successive exposures at 1800 magnifications is shown.

The photomicrography of steel is gone into at some length, several photographs at 3500 magnifications being shown in illustration. Special importance is laid on the preparation of samples as well as on careful focusing.

# Notes on Recent Occurrences

## AWARD OF ELLIOTT CRESSON MEDAL

ON May 16 the Franklin Institute of Philadelphia presented the Elliott Cresson Medal to Gustav W. Elmen of the Bell Telephone Laboratories.

This medal was founded in 1848 by Elliott Cresson of Philadelphia. It is awarded annually for "discovery or original research adding to the sum of human knowledge, irrespective of commercial value and also leading and practical utilizations of discovery."

The award was given to Mr. Elmen for "extended researches in the magnetic characteristics of nickel-iron alloys resulting in permalloy." The remarkable magnetic properties of permalloy render it highly acceptable for use in telephone transformer cores, certain telephone receivers, in the continuous "loading" of submarine telegraph cables for high speed service, and in powdered form for the cores of telephone "loading" coils.

Among other workers in the communication field to whom the Elliott Cresson Medal has been awarded are Dr. Alexander Graham Bell for the electrical transmission of speech; Dr. M. I. Pupin for the "loading" of telephone lines; the American Telephone and Telegraph Company for contributions to the telephone art, and Dr. Lee DeForest for the invention of the three-element thermionic vacuum tube.

## OPERATING CONFERENCE

THE Sixth Operating Conference of the Bell System was held at Absecon, New Jersey, from May 9 to 17, and was attended by the Operating Vice-Presidents and General Managers of the Operating companies and by staff officials of the American Telephone and Telegraph Company.

President Walter S. Gifford talked to the conference regarding "Bell System Policies and Objectives" and

analyzed in detail the policy he enunciated last October before the 1927 Convention of the National Association of Railroad and Utilities Commissioners at Dallas.

There was the usual review and discussion of the results of operations during 1927, and of the outlook for 1928 and subsequent years. Continued and gratifying improvement in the telephone service was evident from the reports of all departments. The toll service particularly, which has shown marked improvement in both speed and quality during the last few years, made further substantial gains and there were also improvements in the handling of local calls including the auxiliary services, such as information and intercept. Installations and moves were completed more promptly and there were fewer plant troubles. Mention should also be made of business office service and improvements were effected both in the service itself and in the appearance and equipment of the offices. Every effort is being made to improve service further in all its elements and an outstanding problem is the private branch exchange. There are a great many of these installations located on subscribers' premises and operated by them, and they are a large factor in telephone service.

Much attention was given to sales activities and their effect on public and customer relations. Without diminishing in any way the activities in all directions, it was generally agreed that there should be a special and system-wide sales effort directed particularly toward increasing the use and convenience of telephones in residences, and increasing the use of toll service, particularly in residences. There appear to be opportunities not only for securing many new residence subscribers, but also for providing additional facilities for existing subscribers, particularly in large residences and apartments where it appears that the telephone service is not used on a basis comparable with other modern comforts and conveniences enjoyed. In this general connection, there was full discussion of the appearance and convenience of the tele-

phone equipment on the subscribers' premises, and sample apparatus was shown which was thought to represent a definite improvement.

In connection with personalization of the service, there were reviews of the studies made by all the companies during the last year as to methods of improving the handling of contacts with subscribers, and it was evident that gratifying progress has been made.

Among many other helpful and interesting matters discussed were further improvements in accident prevention and the appearance of the large motor vehicle fleet of the System. Trials will be made of several colors with the idea of adopting a single color scheme for all cars throughout the System.

## GENERAL COMMERCIAL CONFERENCE

A GENERAL Commercial Conference of the Bell System was held at Shawnee-on-Delaware, Pa., from June 5 to 8, attended by the General Commercial Managers and certain staff representatives of the Associated Companies and of the American Telephone and Telegraph Company.

Among the topics of discussion were sales and customer relations activities throughout the System. It was pointed out that the policy enunciated by Mr. Gifford at Dallas definitely indicates that if the System is to discharge its responsibility and "provide the American public with adequate, dependable, and satisfactory telephone service," sales effort must be carried on. As the scope of service is extended, it becomes, of course, more useful and more adequate, but effort must be made to see that people understand the services offered and how they may be of greater use to them in their social as well as business affairs.

Emphasis was placed upon the importance of developing a sales consciousness throughout the entire organization, and the opportunities which exist for coordinated

effort between all departments to create a public appreciation of the many advantages in using telephone service to as great an extent as luxury, comfort, convenience or business efficiency may dictate. There was general agreement that many benefits were to be gained from a System-wide sales activity directed particularly toward the convenience of the telephone in the home, and a greater use of toll service by residence subscribers, backed up by suitable advertising and publicity. In this connection it was brought out that sales activities should of themselves assist in bringing about improved customer relations.

Attention was also given to the desirability of encouraging a friendly attitude toward the business on the part of customers. Consideration was given to the problems involved in developing a suitable program of customer relations activities for conveying information to customers enabling them to make the best use of their services, and of devising reports and analyses for determining the extent to which customers' desires are being met.

There was discussion of the equipment and facilities necessary to provide residence subscribers with service arrangements more pleasing to them in appearance and convenience. This included consideration of the desirability of special finishes and colors for station equipment, so that it might be in keeping with the surroundings in high class residences and the development of new apparatus such as the proposed dial intercommunicating systems. There was also discussed the importance of having the telephone plant—buildings, outside plant, motor vehicles and station equipment—of pleasing appearance and maintained in such a manner as to create a favorable impression.

Among other matters of particular interest which were brought before the conference were the importance of good business relations with connecting companies, the sale of trade-mark advertising and dealer listings in classified directories on a national basis, and further improvements in the service rendered by business offices.

With respect to the latter, particular stress was laid upon having an adequate number of business offices with management representation, improving the appearance and equipment of business offices, obtaining significant data as to the quality and efficiency of the service rendered, and the selection and training of business office employees.

## UNIVERSITY HONORS FOR AMERICAN COMPANY OFFICIALS

ON June 25th, President Walter S. Gifford received from Williams College the honorary degree of Doctor of Laws.

On May 31st, Vice-President Frank B. Jewett received the honorary degree of Doctor of Engineering from Case School of Applied Science and on June 9th, the honorary degree of Doctor of Science from Rutgers University.

On June 18th, Comptroller C. A. Heiss received the honorary degree of Master of Arts from the University of Michigan.

During the commencement activities at Cornell University, announcement was made of the election of Vice-President Bancroft Gherardi as a trustee.